Einstein's field equations and non-locality

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ABASTRACT

Objective. Reconciling locality and non-locality in accordance with Einstein's general theory of relativity appears to be more than only a hopeless endeavor. Theoretically this seems almost impossible.

Methods.

The usual tensor calculus rules were used.

Results.

Einstein's field equations were simply reformulated in terms of Weyl's curvature tensor without any contradiction, without changing Einstein's field equations at all and without adding anything new to Einstein's field equations.

Conclusions.

Weyl's curvature tensor is not completely identical with non-locality.

Keywords: principium identitatis, principium contradictionis, theory of relativity, Unified field theory, causality

1. Introduction

What is gravity[1] doing over extremely short distances from the point of view of general theory of relativity? Contemporary elementary particle physics or Quantum Field Theory (QFT) as an extension of quantum mechanics (QM) dealing with particles taken seriously in its implications seems to contradict Einstein's general relativity theory especially on this point. To put it another way, it is so hard to reconcile gravitation with QFT because where energy[2], time[3] and space or gravitation[4–6] as such becomes significant QFT is most severely endangered and vice versa. Physicists have spent a lot of time trying to reconcile these two very different theories. To date, relativity and quantum mechanics are two fundamentally different theories with genuinely incompatible descriptions of reality. Nevertheless, authors proposed unified field theories[7] of all natural forces, "*a generalization of the theory of the gravitational field*"[8] including gravitation itself, to bridge the gap between QFT and general relativity theory (i. e. String theory) without a definite success. In this context, the Riemann curvature tensor or Riemann–Christoffel tensor (after Bernhard Riemann and Elwin Bruno Christoffel) is a central mathematical object in the theory of general relativity. However, Weyl curvature tensor, named after Hermann Weyl, is a measure of the curvature of spacetime too and of no less importance. In a similar spirit, the Weyl tensor is the traceless component of the Riemann tensor too. The Weyl curvature tensor differs from the Riemann curvature tensor. The Weyl curvature tensor convey information on how the shape of the body is distorted by the tidal force but does not convey any information on how the volume of the same body changes. The Weyl curvature exists in free space too and governs the propagation of gravitational waves through regions of space devoid of any matter[6,9] and is a component of curvature for Ricci-flat manifolds. Describing Einstein's field equations in terms of Weyl's curvature could be of help to reconcile relativity and quantum mechanics.

2. Material and methods

The Royal Society of London and the Royal Astronomical Society announced[10] the first empirical test of the confirmation of Einstein's general theory of relativity. In order to extend general relativity's geometrization of gravitational force to non-gravitational interactions it appears to be reasonable to assure that new basic physical concepts are in accordance with Einstein's general of relativity[5] too.

2.1 Definitions

The basic rules of tensor calculus can be found in secondary literature too.

Definition 2.1.1(Anti tensor).

Let $a_{\mu\nu}$ denote a certain co-variant tensor. Let $b_{\mu\nu}$, $c_{\mu\nu}$ … denote other tensors. Let $S_{\mu\nu}$ denote another tensor. Let the relationship $a_{\mu\nu} + b_{\mu\nu} + c_{\mu\nu} + \ldots \equiv S_{\mu\nu}$ be given. The **anti tensor** of a tensor $a_{\mu\nu}$, denoted in general as $\underline{a}_{\mu\nu}$, is defined as

$$\begin{aligned} \underline{a}_{\mu\upsilon} &\equiv S_{\mu\upsilon} - a_{\mu\upsilon} \\ &\equiv b_{\mu\upsilon} + c_{\mu\upsilon} + \cdots \end{aligned} \tag{1}$$

There are circumstances were an anti-tensor is identical with an anti-symmetrical tensor, but both are not identical as such.

Definition 2.1.2(Einstein's field equations).

Let $R_{\mu\nu}$ denote the **Ricci tensor**[11] of 'Einstein's general theory of relativity'[5], a geometric object developed by Gregorio Ricci-Curbastro (1853 – 1925) which is able to encapsulate the degree to which a certain geometry of a given metric differs from the geometry of ordinary Euclidean space. Let R denote the **Ricci scalar**, the trace of the Ricci curvature tensor with respect to the metric and equally the simplest curvature invariant of a Riemannian manifold. Ricci scalar curvature is the contraction of the Ricci tensor and is written as R without subscripts or arguments. Let Λ denote the Einstein's cosmological constant. Let $\underline{\Lambda}$ denote the "*anti cosmological constant*"[12]. Let $g_{\mu\nu}$ denote the metric tensor of Einstein's general theory of relativity. Let $G_{\mu\nu}$ denote Einstein's[13] curvature tensor, the trace-reversed Ricci tensor. Let $\underline{G}_{\mu\nu}$ denote the "anti tensor"[14] of Einstein's curvature tensor. Let $E_{\mu\nu}$ denote stress-energy tensor of energy. Let $\underline{E}_{\mu\nu}$ denote tensor of non-energy, the anti-tensor of the stress-energy tensor of energy. Let $a_{\mu\nu}$, $b_{\mu\nu}$, $c_{\mu\nu}$ and $d_{\mu\nu}$ denote the four basic fields of nature were $a_{\mu\nu}$ is the stress-energy tensor of ordinary matter, $b_{\mu\nu}$ is the stress-energy tensor of the electromagnetic field. Let c denote the speed of the light in vacuum, let γ denote Newton's gravitational "constant"[15–18]. Let π denote the number pi. Einstein's field equation, published by Albert Einstein[4] for the first time in 1915, and finally 1916[5] but later with the "cosmological constant"[6] term relate the curvature of spacetime to the energy and momentum as

$$
\begin{aligned}
(R_{\mu\nu}) - \left(\left(\frac{R}{2}\right) \times (g_{\mu\nu})\right) + (\Lambda \times g_{\mu\nu}) &\equiv \left(\frac{4 \times 2 \times \pi \times \gamma}{c^4}\right) \times T_{\mu\nu} \\
&\equiv \left(\frac{2 \times \pi \times \gamma}{c^4}\right) \times 4 \times T_{\mu\nu} \\
&\equiv G_{\mu\nu} + (\Lambda \times g_{\mu\nu}) \\
&\equiv R_{\mu\nu} - \underline{E}_{\mu\nu} \\
&\equiv E_{\mu\nu} \\
&\equiv a_{\mu\nu} + b_{\mu\nu} \\
\mathit{LEFT\ SIDE} &\equiv \mathit{RIGHT\ SIDE}
\end{aligned}
\tag{2}
$$

There are circumstances were an anti-tensor is identical with an anti-symmetrical tensor. However, an anti-tensor and an anti-symmetrical tensor are not identical as such. In point of fact, the left-hand side of the Einstein's field equations represents only one part (Ricci curvature) of the geometric structure (i.e. Weyl curvature).

Definition 2.1.3 (Weyl's tensor).

Let $R_{kl\mu\nu}$ denote the Riemann curvature tensor. Let $W_{kl\mu\nu}$ denote Weyl's[19] curvature tensor, the traceless component of the Riemann tensor $R_{kl\mu\nu}$. Let $\underline{W}_{kl\mu\nu}$ denote anti Weyl's curvature tensor. In general, the Riemann tensor can be split[20] into a symmetric (**massless**) **traceless** Weyl's curvature tensor $W_{kl\mu\nu}$ and a **trace-full massive** part $\underline{W}_{kl\mu\nu}$ as

$$
R_{kl\mu\nu} \equiv \underbrace{W_{kl\mu\nu}}_{Weyl's\ curvature\ tensor} + \underbrace{\underline{W}_{kl\mu\nu}}_{Anti\ Weyl's\ curvature\ tensor}
\tag{3}
$$

The Weyl tensor $W_{kl\mu\nu}$ differs from the Riemann curvature tensor $R_{kl\mu\nu}$. The Weyl tensor $W_{kl\mu\nu}$ does not convey information on how the volume of a certain body changes, but rather how the shape of this body is distorted by tidal forces. In general relativity, the Weyl curvature exists in free space too and is related to the propagation of **gravitational waves**[20,21] through regions of space devoid of matter (vacuum solution of Einstein's field equation). In point of fact, one of the many justified questions is whether there may exist circumstances where the three basic fields of nature $a_{\mu\nu}$, $b_{\mu\nu}$, $c_{\mu\nu}$, (except gravitational waves $d_{\mu\nu}$) are determined as

$$\begin{aligned}(a_{\mu\nu})+(b_{\mu\nu})+(c_{\mu\nu}) &\equiv \underline{W}_{\mu\nu}\\ &\equiv (R_{\mu\nu}) - \left(\underbrace{d_{\mu\nu}}\right)\\ &\equiv (R_{\mu\nu}) - (W_{\mu\nu})\end{aligned} \tag{4}$$

Especially, there is some evidence[22] that Einstein's tensor $G_{\mu\nu}$ is not completely identical with $\underline{W}_{\mu\nu}$. Is it really necessary to accept that

$$\begin{aligned}(d_{\mu\nu}) &\equiv (R_{\mu\nu}) - \left(\underbrace{(a_{\mu\nu})+(b_{\mu\nu})+(c_{\mu\nu})}\right)\\ &\equiv (R_{\mu\nu}) - (\underline{\boldsymbol{W}}_{\mu\nu})\\ &\equiv g^{kl}W_{kl\mu\nu}\\ &\equiv W_{\mu\nu}\end{aligned} \tag{5}$$

Let $L_{kl\mu\nu}$ denote *the locality curvature tensor*. Let $\underline{L}_{kl\mu\nu}$ denote *the non locality curvature tensor*. In general, it is

$$\overbrace{\underline{L}_{kl\mu\nu}}^{Non-locality\ curvature\ tensor} \equiv R_{kl\mu\nu} - \overbrace{L_{kl\mu\nu}}^{Locality\ curvature\ tensor} \tag{6}$$

Let $L_{\mu\nu}$ denote *the tensor of locality*, the contraction of the locality curvature tensor $L_{kl\mu\nu}$. Let $\underline{L}_{\mu\nu}$ denote *the tensor of non locality*, the contraction of the non locality curvature tensor $\underline{L}_{kl\mu\nu}$. In general, it is

$$\begin{aligned}\underline{L}_{\mu\nu} &\equiv g^{kl}R_{kl\mu\nu} - g^{kl}L_{kl\mu\nu}\\ &\equiv R_{\mu\nu} - L_{\mu\nu}\end{aligned} \tag{7}$$

and

$$\begin{aligned}L_{\mu\nu} &\equiv g^{kl}R_{kl\mu\nu} - g^{kl}\underline{L}_{kl\mu\nu}\\ &\equiv R_{\mu\nu} - \underline{L}_{\mu\nu}\end{aligned} \tag{8}$$

Let the tensor $Z_{kl\mu\nu}$ be determined as

$$Z_{kl\mu\nu} \equiv \overbrace{\underline{W}_{kl\mu\nu}}^{Anti\ Weyl's\ curvature\ tensor} - \overbrace{L_{kl\mu\nu}}^{Locality\ curvature\ tensor} \tag{9}$$

Definition 2.1.4 (The Einstein's curvature tensor).

The physics of gravitation as described by general relativity demands that the curvature of spacetime is determined by the presence of energy-momentum to manifest itself as gravity and vice versa. In turn, matter or energy and momentum acts on spacetime to create curvature. Under conditions of Einstein's general theory of relativity, Einstein's tensor of curvature denoted as $G_{\mu\nu}$ is defined/derived/determined as

$$
\begin{aligned}
G_{\mu\nu} &\equiv (R_{\mu\nu}) - \left(\left(\frac{R}{2}\right) \times (g_{\mu\nu})\right) \\
&\equiv a_{\mu\nu} + b_{\mu\nu} + c_{\mu\nu} - b_{\mu\nu} \\
&\equiv a_{\mu\nu} + d_{\mu\nu} + c_{\mu\nu} - d_{\mu\nu} \\
&\equiv a_{\mu\nu} + c_{\mu\nu} \\
&\equiv G \times g_{\mu\nu}
\end{aligned}
\tag{10}
$$

where G is equal to

$$
\begin{aligned}
\boldsymbol{G} &\equiv \boldsymbol{S} - \left(\frac{\boldsymbol{R}}{\boldsymbol{2}}\right) \\
&\equiv \boldsymbol{E} + \boldsymbol{t} - \left(\frac{\boldsymbol{R}}{\boldsymbol{2}}\right) \\
&\equiv \left(\frac{\boldsymbol{2} \times \boldsymbol{\pi} \times \boldsymbol{\gamma} \times \boldsymbol{T}}{\boldsymbol{c^4}}\right) + \left(\frac{\boldsymbol{R}}{\boldsymbol{2}} - \boldsymbol{\Lambda}\right) - \left(\frac{\boldsymbol{R}}{\boldsymbol{2}}\right) \\
&\equiv \left(\frac{\boldsymbol{2} \times \boldsymbol{\pi} \times \boldsymbol{\gamma} \times \boldsymbol{T}}{\boldsymbol{c^4}}\right) - \boldsymbol{\Lambda}
\end{aligned}
\tag{11}
$$

Definition 2.1.5 (The tensor of non-energy).
Under conditions of Einstein's general theory of relativity, the tensor of non-energy, denoted as $\underline{E}_{\mu\nu}$, or the anti tensor of the stress energy tensor of energy is defined/derived/determined as follows:

$$
\begin{aligned}
\underline{E}_{\mu\nu} &\equiv (R_{\mu\nu}) - \left(\frac{4 \times 2 \times \pi \times \gamma}{c^4}\right) \\
&\equiv \left(\left(\frac{R}{2}\right) \times (g_{\mu\nu})\right) - (\Lambda \times g_{\mu\nu}) \\
&\equiv \left(\frac{R}{2} - \Lambda\right) \times g_{\mu\nu} \\
&\equiv c_{\mu\nu} + d_{\mu\nu} \\
&\equiv \underline{E} \times g_{\mu\nu} \\
&\equiv t \times g_{\mu\nu}
\end{aligned}
\tag{12}
$$

where

$$
t \equiv \underline{E} \equiv \left(\frac{R}{2} - \Lambda\right)
\tag{13}
$$

Definition 2.1.6 (The anti Einstein's curvature tensor $\underline{G}_{\mu\nu}$ or the tensor or non-curvature).
Under conditions of Einstein's general theory of relativity, the anti Einstein tensor, the tensor of non-curvature, denoted as $\underline{G}_{\mu\nu}$, is defined/derived/determined

$$
\begin{aligned}
\underline{G}_{\mu\nu} &\equiv (R_{\mu\nu}) - (G_{\mu\nu}) \\
&\equiv (R_{\mu\nu}) - \overbrace{\left(R_{\mu\nu} - \left(\frac{R}{2}\right) \times (g_{\mu\nu})\right)} \\
&\equiv \left(\frac{R}{2}\right) \times (g_{\mu\nu}) \\
&\equiv a_{\mu\nu} + b_{\mu\nu} + c_{\mu\nu} + d_{\mu\nu} - a_{\mu\nu} - c_{\mu\nu} \\
&\equiv b_{\mu\nu} + d_{\mu\nu} \\
&\equiv \underline{G} \times g_{\mu\nu}
\end{aligned}
\tag{14}
$$

where $\underline{G} = (R/2)$.

Definition 2.1.7 (The tensor $d_{\mu\nu}$ (neither curvature nor momentum)).

Under conditions of Einstein's general theory of relativity, the tensor of neither curvature nor momentum, denoted as $d_{\mu\nu}$, is defined/derived/determined as follows:

$$
\begin{aligned}
d_{\mu\nu} &\equiv \left(\frac{R}{2}\right) \times (g_{\mu\nu}) - (b_{\mu\nu}) \\
&\equiv \left(\frac{R}{2} \times (g_{\mu\nu})\right) - (\Lambda \times (g_{\mu\nu})) - (c_{\mu\nu}) \\
&\equiv d \times g_{\mu\nu}
\end{aligned}
\tag{15}
$$

where

$$
\begin{aligned}
d &\equiv \left(\frac{R}{2}\right) - b \\
&\equiv \left(\frac{R}{2}\right) - \left(\left(\frac{1}{4 \times 4 \times \pi}\right) \times \left((F_{\mu c} \times F^{\mu c}) - (F_{de} \times F^{de})\right)\right)
\end{aligned}
\tag{16}
$$

while F is called the (traceless) Faraday/electromagnetic/field strength tensor. Under which conditions is it given that

$$
\begin{aligned}
W_{\mu\nu} &\equiv \left(\frac{R}{2}\right) \times (g_{\mu\nu}) - (b_{\mu\nu}) \\
&\equiv \left(\frac{R}{2} \times (g_{\mu\nu})\right) - (\Lambda \times (g_{\mu\nu})) - (c_{\mu\nu}) \\
&\equiv d \times g_{\mu\nu}
\end{aligned}
\tag{17}
$$

Definition 2.1.8 (The tensor $c_{\mu\nu}$).

Under conditions of Einstein's general theory of relativity, the tensor of non-momentum and curvature, denoted as $c_{\mu\nu}$, is defined/derived/determined as follows:

$$
\begin{aligned}
c_{\mu\nu} &\equiv (G_{\mu\nu}) - (a_{\mu\nu}) \\
&\equiv \overbrace{(a_{\mu\nu}) + (c_{\mu\nu})} - (a_{\mu\nu}) \\
&\equiv \underbrace{\left(\frac{R}{2} \times (g_{\mu\nu})\right) - (\Lambda \times (g_{\mu\nu}))} - (d_{\mu\nu}) \\
&\equiv (c_{\mu\nu}) + (d_{\mu\nu}) - (d_{\mu\nu}) \\
&\equiv (b_{\mu\nu}) - (\Lambda \times (g_{\mu\nu})) \\
&\equiv c \times g_{\mu\nu}
\end{aligned}
\tag{18}
$$

where c is equal to

$$
c \equiv \left(\left(\frac{1}{4 \times 4 \times \pi}\right) \times \left((F_{\mu c} \times F^{\mu c}) - (F_{de} \times F^{de})\right)\right) - \Lambda \tag{19}
$$

Definition 2.1.9 (The tensor $b_{\mu\nu}$).
The co-variant stress-energy tensor of the electromagnetic field, in this context denoted by $b_{\mu\nu}$, is of order two while its components can be displayed by a 4×4 matrix too. Under conditions of Einstein's general theory of relativity, the tensor $b_{\mu\nu}$ denotes the stress-energy tensor of the electromagnetic field expressed more compactly and, in a coordinate independent form as

$$
\begin{aligned}
b_{\mu\nu} &\equiv (E_{\mu\nu}) - (a_{\mu\nu}) \\
&\equiv \overbrace{(a_{\mu\nu}) + (b_{\mu\nu})} - (a_{\mu\nu}) \\
&\equiv \left(\frac{R}{2} \times (g_{\mu\nu})\right) - (d_{\mu\nu}) \\
&\equiv \overbrace{(b_{\mu\nu}) + (d_{\mu\nu})} - (d_{\mu\nu}) \\
&\equiv \left(\frac{1}{4 \times 4 \times \pi}\right) \times \left((F_{\mu c} \times F^{\mu c}) - (F_{de} \times F^{de})\right) \times g_{\mu\nu} \\
&\equiv b \times g_{\mu\nu}
\end{aligned}
\tag{20}
$$

where (as can be seen in the following of this paper) it is

$$
b \equiv \left(\left(\frac{1}{4 \times 4 \times \pi}\right) \times \left((F_{\mu c} \times F^{\mu c}) - (F_{de} \times F^{de})\right)\right) \tag{21}
$$

while F is called the (traceless) Faraday/electromagnetic/field strength tensor.

Definition 2.1.10 (The stress-energy tensor of ordinary matter $a_{\mu\nu}$).
Under conditions of Einstein's general theory of relativity, the stress-energy tensor of ordinary matter, denoted as $a_{\mu\nu}$, is defined/derived/determined as follows:

$$
\begin{aligned}
a_{\mu\nu} &\equiv a_{\mu\nu} + b_{\mu\nu} - b_{\mu\nu} \\
&\equiv a_{\mu\nu} + c_{\mu\nu} - c_{\mu\nu} \\
&\equiv \left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) \times g_{\mu\nu} \\
&\quad - \Bigg(\left(\frac{1}{4 \times 4 \times \pi}\right) \times \left(\left(F_{\mu c} \times F^{\mu c}\right) - \left(F_{de} \times F^{de}\right)\right) \Bigg) \times g_{\mu\nu} \\
&\equiv R_{\mu\nu} - b_{\mu\nu} - c_{\mu\nu} - d_{\mu\nu} \\
&\equiv G_{\mu\nu} + \left(\Lambda \times \left(g_{\mu\nu}\right)\right) - b_{\mu\nu} \\
&\equiv a \times g_{\mu\nu}
\end{aligned}
\tag{22}
$$

while

$$
a \equiv \left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) - \Bigg(\left(\frac{1}{4 \times 4 \times \pi}\right) \times \left(\left(F_{\mu c} \times F^{\mu c}\right) - \left(F_{de} \times F^{de}\right)\right) \Bigg)
\tag{23}
$$

Definition 2.1.11 (The stress-energy momentum tensor $E_{\mu\nu}$).
Under conditions of Einstein's general theory of relativity, the stress-energy momentum tensor, denoted as $E_{\mu\nu}$, is defined/derived/determined as follows:

$$\begin{aligned}
(E_{\mu v}) &\equiv \left(\frac{4 \times 2 \times \pi \times \gamma}{c^4}\right) \times T_{\mu v} \\
&\equiv \left(\frac{2 \times \pi \times \gamma}{c^4}\right) \times 4 \times T_{\mu v} \\
&\equiv \left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) \times g_{\mu v} \\
&\equiv a_{\mu v} + b_{\mu v} \\
&\equiv \underbrace{(R_{\mu v}) - \left(\left(\frac{R}{2}\right) \times (g_{\mu v})\right)} + \Lambda \times g_{\mu v} \\
&\equiv G_{\mu v} + \Lambda \times g_{\mu v} \\
&\equiv \overbrace{a_{\mu v} + c_{\mu v}} + (\Lambda \times g_{\mu v}) \\
&\equiv R_{\mu v} - \underline{E}_{\mu v} \\
&\equiv E \times g_{\mu v}
\end{aligned} \tag{24}$$

while E is determined a

$$E \equiv \left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) \tag{25}$$

Definition 2.1.12 (The Ricci tensor $R_{\mu\nu}$).

Under conditions of Einstein's general theory of relativity, the Ricci tensor, denoted a $R_{\mu\nu}$, is defined/derived/determined as follows:

$$\begin{aligned}
R_{\mu v} &\equiv a_{\mu v} + b_{\mu v} + c_{\mu v} + d_{\mu v} \\
&\equiv \overbrace{\underbrace{\left(\frac{4 \times 2 \times \pi \times \gamma}{c^4}\right) \times T_{\mu v}}} + \overbrace{\underbrace{\left(\left(\frac{R}{2}\right) \times (g_{\mu v})\right) - (\Lambda \times g_{\mu v})}} \\
&\equiv E_{\mu v} + \underline{E}_{\mu v} \\
&\equiv G_{\mu v} + \underline{G}_{\mu v} \\
&\equiv (E + t) \times g_{\mu v} \\
&\equiv S \times g_{\mu v}
\end{aligned} \tag{26}$$

while S is defined/derived/determined as follows:

$$\begin{aligned}
S &\equiv E + t \\
&\equiv \left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) + \left(\frac{R}{2} - \Lambda\right)
\end{aligned} \tag{27}$$

Definition 2.1.13 (The Ricci scalar R).

Under conditions of Einstein's general theory of relativity, the Ricci scalar curvature R as the trace of the Ricci curvature tensor $R_{\mu\nu}$ with respect to the metric tensor $g_{\mu\nu}$ is determined at each point in space-time by lamda Λ and *anti-lamda* $\underline{\Lambda}$ [12] as

$$\begin{aligned} R &\equiv g^{\mu\upsilon} \times R_{\mu\upsilon} \\ &\quad g^{\mu\upsilon} \times \overbrace{g_{\mu\upsilon} \times S} \\ &\equiv \underbrace{g^{\mu\upsilon} \times g_{\mu\upsilon}} \times S \\ &\equiv 4 \times S \\ &\equiv \Lambda + \underline{\Lambda} \end{aligned} \tag{28}$$

From this definition follows the relationship S = (R/4) or that

$$\frac{R}{S} \equiv +4 \equiv g^{\mu\upsilon} \times g_{\mu\upsilon} \tag{29}$$

A Ricci scalar curvature *R* which is *positive* at a certain point indicates that the volume of a small ball about the point has smaller volume than a ball of the same radius in Euclidean space. In contrast to this, a *Ricci* scalar curvature R which is *negative* at a certain point indicates that the volume of a small ball is larger than it would be in Euclidean space. In general, we obtain

$$R \times g_{\mu\upsilon} \equiv \left(\Lambda \times g_{\mu\upsilon}\right) + \left(\underline{\Lambda} \times g_{\mu\upsilon}\right) \tag{30}$$

or

$$(4 \times S) \times g_{\mu\upsilon} \equiv \left(\Lambda \times g_{\mu\upsilon}\right) + \left(\underline{\Lambda} \times g_{\mu\upsilon}\right) \tag{31}$$

or

$$S \times g_{\mu\upsilon} \equiv \left(\frac{\Lambda}{4} \times g_{\mu\upsilon}\right) + \left(\frac{\underline{\Lambda}}{4} \times g_{\mu\upsilon}\right) \tag{32}$$

or

$$R_{\mu\upsilon} \equiv \mathrm{S} \times g_{\mu\upsilon} \equiv \left(\frac{\Lambda}{4} \times g_{\mu\upsilon}\right) + \left(\frac{\underline{\Lambda}}{4} \times g_{\mu\upsilon}\right) \tag{33}$$

Einstein's field equations are determined as

$$R_{\mu\upsilon} - \left(\left(\frac{R}{2}\right) \times \left(g_{\mu\upsilon}\right)\right) + \Lambda \times g_{\mu\upsilon} \equiv \left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) \times g_{\mu\upsilon} \tag{34}$$

Rearranging we obtain

$$R_{\mu\upsilon} - \left(\left(\frac{R}{2}\right) \times \left(g_{\mu\upsilon}\right)\right) - \left(\left(\frac{R}{2}\right) \times \left(g_{\mu\upsilon}\right)\right) + \Lambda \times g_{\mu\upsilon} \equiv \left(\left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) \times g_{\mu\upsilon}\right) - \left(\left(\frac{R}{2}\right) \times \left(g_{\mu\upsilon}\right)\right) \tag{35}$$

or

$$R_{\mu\upsilon} - \left(R \times \left(g_{\mu\upsilon}\right) - \Lambda \times g_{\mu\upsilon}\right) \equiv \left(\left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) \times g_{\mu\upsilon}\right) - \left(\left(\frac{R}{2}\right) \times \left(g_{\mu\upsilon}\right)\right) \tag{36}$$

or

$$R_{\mu\upsilon} + \left(\left(\frac{R}{2}\right) \times \left(g_{\mu\upsilon}\right)\right) - \left(\left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) \times g_{\mu\upsilon}\right) \equiv \left(R \times \left(g_{\mu\upsilon}\right) - \Lambda \times g_{\mu\upsilon}\right) \tag{37}$$

The *anti lamda field* can be derived from Einstein's field equation as

$$\underline{\Lambda} \times g_{\mu\nu} \equiv R_{\mu\nu} + \left(\left(\frac{R}{2}\right) \times \left(g_{\mu\nu}\right)\right) - \left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) \times g_{\mu\nu} \tag{38}$$

In other words, the anti lamda field can be simplified as

$$\underline{\Lambda} \times g_{\mu\nu} \equiv \left(S + \left(\frac{R}{2}\right) - \left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right)\right) \times g_{\mu\nu} \tag{39}$$

However, doubts are more than justified whether there can be identified any kind of a particle which can be ascribed to such a more or less purely artificial and unrealistic field without any practical significance. Mathematics' as one product of human mind and imagination can reach us far while reality need not to follow at all. Nonetheless, as found before, it is S = (R/4) and *anti lambda* $\underline{\Lambda}$ can be calculated as

$$\begin{aligned} \underline{\Lambda} &\equiv \left(S + \left(\frac{R}{2}\right) - \left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right)\right) \\ &\equiv \left(\left(\frac{R}{4}\right) + \left(\frac{R}{2}\right) - \left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right)\right) \end{aligned} \tag{40}$$

or as

$$\underline{\Lambda} \equiv \left(\left(\frac{3 \times R}{4}\right) - \left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right)\right) \tag{41}$$

The cosmological constant Λ can also be written algebraically as part of the stress–energy tensor of energy/matter, a second order tensor as the source of gravity (energy density). In this context, the cosmological constant Λ can be determined as

$$\Lambda \equiv \left(\left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) + \left(\frac{R}{4}\right)\right) \tag{42}$$

which forces us to accept that

$$\left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) \equiv \left(\Lambda - \left(\frac{R}{4}\right)\right) \tag{43}$$

Table 1 may provide a preliminary overview of the definitions of the four basic fields of nature.

		Curvature		
		Yes	No	
Momentum	Yes	$\mathbf{a_{\mu\nu}}$	$\mathbf{b_{\mu\nu}}$	$E \times g_{\mu\nu}$
	No	$\mathbf{c_{\mu\nu}}$	$\mathbf{d_{\mu\nu}}$	$\underline{t} \times g_{\mu\nu}$
		$G_{\mu\nu}$	$\underline{G}_{\mu\nu}$	$S \times g_{\mu\nu}$

Table 1. Four basic fields of nature

Einstein's field equations simplify as

$$\left(S \times g_{\mu\upsilon}\right) - \left(t \times g_{\mu\upsilon}\right) \equiv \left(E \times g_{\mu\upsilon}\right) \tag{44}$$

Under conditions where the Hamiltonian operator H is equal to **H=E**, the Hamiltonian operator and the wave function ψ is equal[23] to **ψ =t**, Einstein's field equations becomes

$$\left(S \times g_{\mu\upsilon}\right) - \left(\psi \times g_{\mu\upsilon}\right) \equiv \left(H \times g_{\mu\upsilon}\right) \tag{45}$$

Definition 2.1.14 (The inverse metric tensor $g^{\mu\nu}$ and the metric tensor $g_{\mu\nu}$).
Under conditions of Einstein's general[5] theory of relativity, it is

$$g^{\mu\upsilon} \times g_{\mu\upsilon} \equiv +4 \tag{46}$$

or

$$\frac{1}{g^{\mu\upsilon}} \times \frac{1}{g_{\mu\upsilon}} \equiv \frac{1}{+4} \tag{47}$$

where $g^{\mu\nu}$ is the matrix inverse of the metric tensor $g_{\mu\nu}$. The inverse metric tensor or the metric tensor, which is always symmetric, allow tensors to be transformed into each other. Einstein replaced the scalar Newtonian gravitational potential from Poisson's equation for gravity in general relativity by the metric tensor $g_{\mu\nu}$. Einstein's emphasizes this issue using the following statement *"... in the general theory of relativity ... must be ... the tensor $g_{\mu\nu}$ of the gravitational potential*"[24 (p. 88)]

Definition 2.1.15 (Laue's scalar T).
Max von Laue (1879-1960) proposed a scalar[25] as the contraction or as the trace of the stress–energy momentum tensor $T_{\mu\nu}$, denoted as T and written without subscripts or arguments. However, Einstein himself criticized Laue's scalar[26] T. Under conditions of Einstein's general[5] theory of relativity, it is

$$T \equiv g^{\mu\upsilon} \times T_{\mu\upsilon} \tag{48}$$

where $T_{\mu\nu}$ "*denotes the co-variant energy tensor of matter*" [24 (p. 88)]. Einstein explained further in the text: "*Considered phenomenologically, this energy tensor is composed of that of the electromagnetic field and of matter in the narrower sense*." [24 (p. 93)]

Definition 2.1.16 (Index raising).
For an order-2 tensor, twice multiplying by the contra-variant metric tensor and contracting in different indices[27] raises each index. In simple words, it is

$$F^{\substack{1\ 3\\ \mu\ c}} \equiv g^{\substack{1\ 2\\ \mu\ \upsilon}} \times g^{\substack{3\ 4\\ c\ d}} \times F_{\substack{\upsilon\ d\\ 2\ 4}} \tag{49}$$

or more professionally

$$F^{\mu c} \equiv g^{\mu\upsilon} \times g^{cd} \times F_{\upsilon d} \tag{50}$$

2.2 Axioms

2.2.1 Axioms in general

Making errors is indeed only human. However, it is important to be able to recognize erroneous thinking as such. Axioms[28] and rules chosen carefully can be of use to recognize and to avoid logical inconsistency and equally may be of help to prevent science from supporting particular ideologies. Rightly or wrongly, long lasting advances in our knowledge of nature are enabled by suitable axioms[29] too. In this context, Einstein himself reiterates again the importance of implementing axioms in science. "*Die wahrhaft großen Fortschritte der Naturerkenntnis sind auf einem der Induktion fast diametral entgegengesetzten Wege entstanden*."[30 (p. 17)] Einstein's previous position now been translated into English: *The truly great advances in our understanding of nature originated in a manner almost diametrically opposed to induction*. It is worth mentioning in this matter, Einstein himself advocated especially basic laws (axioms) and conclusions derived from such axioms as a main logical foundation of any 'theory'. "*Grundgesetz (Axiome) und Folgerungen zusammen bilden das was man eine 'Theorie' nennt*." [30 (p. 17)] Albert Einstein's (1879-1955) message translated into English as: "*Basic law (axioms) and conclusions together form what is called a 'theory'* " has still to get round. However, it is currently difficult to ignore completely these historical and far reaching words of wisdom. The same taken more seriously and put into practice, will yield an approach to fundamental scientific problems which is more creative and sustainably logically consistent. Historically, Aristotle himself already cited *the law of excluded middle* and *the law of contradiction* as examples of axioms. However, *lex identitatis* is an axiom too, which possess the potential to serve as the most basic and equally as the simplest axiom of science. Something which is really just itself is equally different from everything else. In point of fact, is such an equivalence which everything has to itself inherent or must the same be constructed by human mind and consciousness. Following Gottfried Wilhelm Leibniz (1646-1716): "*Chaque chose est ce qu'elle est. Et dans autant d'exemples qu'on voudra A est A, B est B.*" [31 (p. 327)] or A = A, B = B or +1 = +1. In this context, lex contradictionis, the negative of lex identitatis, or +0 = +1 is of no minor importance too.

2.2.2 Axiom I. Lex identitatis

To say that +1 is identical to +1 is to say that both are the same.

AXIOM1. LEX IDENTITATIS.

$$g^{\mu\upsilon} \times g_{\mu\upsilon} - 3 \equiv +1 \tag{51}$$

or

$$+1 \equiv +1 \tag{52}$$

However, even such a numerical identity which seems in itself wholly unproblematic, for it indicates just to a relation which something has to itself and nothing else, is still subject to controversy. Another increasingly popular view is that the same numerical identity implies the controversial view that we are talking about two different numbers +1. The one +1 is on the left side on the equation, the other +1 is on the right side of an equation. The basicness of the relation of identity implies the contradiction too while circularity is avoided. In other words, how can the same +1 be identical with itself and be equally different from itself? We may usefully state that identity is an utterly problematic notion and might be the most troublesome of all.

2.2.3 Axiom II. Lex contradictionis

AXIOM2. LEX CONTRADICTIONIS.

$$\left(\left(g^{\mu\nu} \times g_{\mu\nu}\right) - 3\right) \; - \; \left(\left(g^{\mu\nu} \times g_{\mu\nu}\right) - 3\right) \; \equiv \; +1 \tag{53}$$

or

$$+0 \; \equiv \; +1 \tag{54}$$

A considerable obstacle to understanding contemporary usage of the term contradiction, however, is that contradiction does not seem to be a unitary one. How can something be both, itself (a path is a straight line from the standpoint of a co-moving observer at a certain point in space-time) and the other of itself, its own opposition (the same path is not a straight line, the same path is curved, from the standpoint of a stationary observer at a certain point in space-time)[32]. We may simply deny the existence of objective or of any other contradictions. However, even if it remains justified especially according to Einstein's special theory of relativity that it is not guaranteed that the notion of an absolute contradiction is not secured, Einstein's special theory of relativity insist that contradictions are objective and real[32]. This fact highlights and implies the question too, why should and how can an identical be a contradictory too?

2.2.4 Axiom III. Lex negationis

AXIOM3. LEX NEGATIONIS.

$$\neg \times 0 \; \equiv \; +1 \tag{55}$$

where ¬ denotes the (natural "*determinatio negatio est*"[33]/logical[34]) process of negation[35].

Theorem 3.1 (THE GEOMETRICAL FORM OF THE STRESS-ENERGY TENSOR OF THE ELECTROMAGNETIC FIELD $b_{\mu\nu}$).

All mater considered as some deformation of space-time would enable a combined theory of electromagnetism and gravitation in terms of geometry too. However, it is of course quite natural to ask whether nature's all (long range) fields (of force) have a common origin at all? In particular, is the electromagnetic field a property of spacetime or merely something being embedded in spacetime? Einstein's mathematics of the theory of general relativity related the gravitational field to the curvature of spacetime, while the electromagnetic field remains completely unrelated to the spacetime geometry. Unfortunately, the geometrization of the electromagnetic fields within the frame of Einstein's theory of general relativity has been left behind by Einstein as an unsolved problem. In recent years, the work on the geometrization of electromagnetism has begun to increase. Many different trials proposed its own way to extend the geometry of general relativity that would, so it seemed, serve as a geometrization of the electromagnetic field as well. However, the most of these trials[36–38] were thus far not widely accepted or are totally ignored by scientific community. While wrong papers don't make it through history on the long run, we will have to face the fact that the obvious public ignorance of such publications appears to provide a kind of an indirect proof that these and similar papers are simply wrong because ignoring the same suffices to date. With regard to the conceptual differences between the geometrized gravitational field and the classical Maxwellian theory of the electromagnetic filed the obviously more than insurmountable old borders remain at least in scientist's consciousness. Nonetheless and needless to say that only a minority of inveterate optimists try once and again to dispute accepted wisdom in this context.

CLAIM.

In general, the completely geometrical form of the stress-energy momentum tensor of the electromagnetic field $b_{\mu\nu}$ is given by

$$b_{\mu\nu} \equiv \left(\left(\frac{1}{4 \times 4 \times \pi}\right) \times \left(\left(F_{\mu c} \times F^{\mu c}\right) - \left(F_{de} \times F^{de}\right)\right)\right) \times g_{\mu\nu} \tag{56}$$

PROOF BY MODUS PONENS.

If the premise of modus ponens

$$(+1) \equiv (+1) \tag{57}$$

is true, **then** the following conclusion

$$b_{\mu\nu} \equiv \left(\left(\frac{1}{4 \times 4 \times \pi}\right) \times \left(\left(F_{\mu c} \times F^{\mu c}\right) - \left(F_{de} \times F^{de}\right)\right)\right) \times g_{\mu\nu} \tag{58}$$

is also true, the absence of any technical errors presupposed. The premise

$$(+1) \equiv (+1) \tag{59}$$

is true. Multiplying this premise by the stress-energy momentum tensor of the electromagnetic field $b_{\mu\nu}$, we obtain

$$(+1) \times b_{\mu\nu} \equiv (+1) \times b_{\mu\nu} \tag{60}$$

or

$$b_{\mu\nu} \equiv b_{\mu\nu} \tag{61}$$

Rearranging equation according to the definition above, it is

$$b_{\mu\nu} \equiv \left(\frac{1}{4 \times \pi}\right) \times \left(\left(\left(F_{\mu c} \times F_{\nu d} \times g^{cd}\right)\right) - \left(\left(\frac{1}{4}\right) \times \left(F_{de} \times F^{de}\right) \times g_{\mu\nu}\right)\right) \tag{62}$$

Rearranging equation before again it is

$$b_{\mu\nu} \equiv \left(\frac{1}{4 \times \pi}\right) \times \left(\left(1 \times \left(F_{\mu c} \times F_{\nu d} \times g^{cd}\right)\right) - \left(\frac{\left(F_{de} \times F^{de}\right)}{4}\right) \times g_{\mu\nu}\right) \tag{63}$$

and equally

$$b_{\mu\upsilon} \equiv \left(\frac{1}{4\times\pi}\right)\times\left(\left(\frac{4\times\left(F_{\mu c}\times F_{\upsilon d}\times g^{cd}\right)}{4}\right)-\left(\frac{\left(F_{de}\times F^{de}\right)}{4}\right)\times g_{\mu\upsilon}\right) \tag{64}$$

According to definition above, this equation simplifies as

$$b_{\mu\upsilon} \equiv \left(\frac{1}{4\times\pi}\right)\times\left(\left(\frac{\left(g^{\mu\upsilon}\times g_{\mu\upsilon}\right)\times\left(F_{\mu c}\times F_{\upsilon d}\times g^{cd}\right)}{4}\right)-\left(\frac{\left(F_{de}\times F^{de}\right)}{4}\right)\times g_{\mu\upsilon}\right) \tag{65}$$

and equally as

$$b_{\mu\upsilon} \equiv \left(\frac{1}{4\times\pi}\right)\times\left(\left(\left(\frac{\left(g^{\mu\upsilon}\times F_{\mu c}\times F_{\upsilon d}\times g^{cd}\right)}{4}\right)\times g_{\mu\upsilon}\right)-\left(\left(\frac{\left(F_{de}\times F^{de}\right)}{4}\right)\times g_{\mu\upsilon}\right)\right) \tag{66}$$

A further simplification of the relationship before yields the stress-energy momentum tensor of the electromagnetic field $b_{\mu\nu}$ determined by the metric tensor of general relativity $g_{\mu\nu}$ as

$$b_{\mu\upsilon} \equiv \left(\left(\frac{1}{4\times\pi}\right)\times\left(\left(\frac{1}{4}\right)\times\left(\left(F_{\mu c}\times g^{\mu\upsilon}\times g^{cd}\times F_{\upsilon d}\right)-\left(F_{de}\times F^{de}\right)\right)\right)\right)\times g_{\mu\upsilon} \tag{67}$$

However, the term

$$\left(\left(\frac{1}{4}\right)\times\left(\left(F_{\mu c}\times g^{\mu\upsilon}\times g^{cd}\times F_{\upsilon d}\right)-\left(F_{de}\times F^{de}\right)\right)\right) \tag{68}$$

of the equation before can be simplified further. For an order-2tensor, twice multiplying by the contra-variant metric tensor and contracting in different indices[27] raises each index. In other words, it is according to definition view lines before

$$F^{\mu c} \equiv g^{\mu\upsilon} \times g^{cd} \times F_{\upsilon d} \tag{69}$$

which simplifies the term before as

$$\left(\left(\frac{1}{4}\right)\times\left(\left(F_{\mu c}\times F^{\mu c}\right)-\left(F_{de}\times F^{de}\right)\right)\right) \tag{70}$$

or as

$$\left(\frac{1}{4}\right)\times\left(\left(F_{\mu c}\times F^{\mu c}\right)-\left(F_{de}\times F^{de}\right)\right) \tag{71}$$

This relationship simplifies the geometrical form of the stress-energy momentum tensor of the electromagnetic field $b_{\mu\nu}$ further as

$$b_{\mu\upsilon} \equiv \left(\left(\frac{1}{4\times 4\times\pi}\right)\times\left(\left(F_{\mu c}\times F^{\mu c}\right)-\left(F_{de}\times F^{de}\right)\right)\right)\times g_{\mu\upsilon} \tag{72}$$

while F is called the (traceless) Faraday/electromagnetic/field strength tensor. The stress-energy momentum tensor of the electromagnetic field is geometrized completely, our conclusion is true.

QUOD ERAT DEMONSTRANDUM.

Theorem 3.2 (THE GEOMETRICAL FORM OF THE STRESS-ENERGY TENSOR OF EENERGY/MATTER).

The starting point of Einstein's theory of general relativity was that gravity as such is at least a property of space-time geometry. Consequently, Einstein published[5] a geometric theory of gravitation while Einstein's initial hope to construct a purely geometric theory of gravitation in which even the sources of gravitation themselves would be of geometric origin has still not been fulfilled. Einstein's field equations have a source term, the stress-energy tensor of matter, radiation, vacuum et cetera, which is of order two and is still devoid of any geometry and free of any geometrical significance.

CLAIM.

In general, the completely geometrical form of the stress-energy momentum tensor of Einstein's theory of general relativity is given by

$$\left(\frac{8\times\pi\times\gamma}{c^4}\right)\times T_{\mu\upsilon} \equiv \left(\frac{2\times\pi\times\gamma\times T}{c^4}\right)\times g_{\mu\upsilon} \tag{73}$$

PROOF BY MODUS PONENS.

If the premise of modus ponens

$$(+1) \equiv (+1) \tag{74}$$

is true, **then** the following conclusion

$$\left(\frac{8\times\pi\times\gamma}{c^4}\right)\times T_{\mu\upsilon} \equiv \left(\frac{2\times\pi\times\gamma\times T}{c^4}\right)\times g_{\mu\upsilon} \tag{75}$$

is also true, the absence of any technical errors presupposed. The premise

$$(+1) \equiv (+1) \tag{76}$$

is true. Multiplying this premise by the stress-energy momentum tensor of matter, we obtain

$$(+1)\times\left(\left(\frac{8\times\pi\times\gamma}{c^4}\right)\times T_{\mu\upsilon}\right) \equiv (+1)\times\left(\left(\frac{8\times\pi\times\gamma}{c^4}\right)\times T_{\mu\upsilon}\right) \tag{77}$$

or

$$\left(\left(\frac{8\times\pi\times\gamma}{c^4}\right)\times T_{\mu\upsilon}\right) \equiv \left(\left(\frac{8\times\pi\times\gamma}{c^4}\right)\times T_{\mu\upsilon}\right) \tag{78}$$

This equation simplifies as

$$\left(\left(\frac{8\times\pi\times\gamma}{c^4}\right)\times T_{\mu\upsilon}\right) \equiv \left(\left(\frac{2\times\pi\times\gamma}{c^4}\right)\times 4\times T_{\mu\upsilon}\right) \tag{79}$$

According to definition above this equation is rearranged as

$$\left(\left(\frac{8 \times \pi \times \gamma}{c^4}\right) \times T_{\mu\upsilon}\right) \equiv \left(\left(\frac{2 \times \pi \times \gamma}{c^4}\right) \times \left(g_{\mu\upsilon} \times g^{\mu\upsilon}\right) \times T_{\mu\upsilon}\right) \tag{80}$$

or as

$$\left(\left(\frac{8 \times \pi \times \gamma}{c^4}\right) \times T_{\mu\upsilon}\right) \equiv \left(\left(\frac{2 \times \pi \times \gamma}{c^4}\right) \times \left(g^{\mu\upsilon} \times T_{\mu\upsilon}\right) \times \left(g_{\mu\upsilon}\right)\right) \tag{81}$$

Referring to the definition of Laue's scalar T, this equation can be rearranged as

$$\left(\left(\frac{8 \times \pi \times \gamma}{c^4}\right) \times T_{\mu\upsilon}\right) \equiv \left(\left(\frac{2 \times \pi \times \gamma}{c^4}\right) \times T \times \left(g_{\mu\upsilon}\right)\right) \tag{82}$$

The desired geometrical representation of the stress-energy momentum tensor energy/matter of Einstein's general theory of relativity follows as

$$\left(\frac{8 \times \pi \times \gamma}{c^4}\right) \times T_{\mu\upsilon} \equiv \left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) \times g_{\mu\upsilon} \tag{83}$$

In other words, our conclusion is true.
QUOD ERAT DEMONSTRANDUM.

Remark.
From the geometrical point of view the stress–energy momentum tensor of energy/matter $E_{\mu\nu}$ is more or less identical with the metric tensor $g_{\mu\nu}$, enriched only by view constants and a scalar as

$$E_{\mu\upsilon} \equiv \left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) \times g_{\mu\upsilon} \tag{84}$$

Using geometrized units where $\gamma = c = 1$, the geometrical form of the stress–energy momentum tensor of energy/matter $E_{\mu\nu}$ can be rewritten as

$$E_{\mu\upsilon} \equiv (2 \times \pi \times T) \times g_{\mu\upsilon} \tag{85}$$

However, describing the fundamental stress–energy momentum tensor energy/matter, the source term of the gravitational field in Einstein's general theory of relativity, as an inherent geometrical structure, as being determined or dependent on the metric field $g_{\mu\nu}$ is associated with several and far reaching consequences. Theoretically, the properties of energy, momentum, mass, stress et cetera need no longer to be seen as intrinsic properties of matter with the consequence that the properties which material systems possess could be determined in virtue of their relation to space-time structures too. The question thus far arises whether the energy tensor $E_{\mu\nu}$ at the end could be in different aspects less fundamental than the metric field $g_{\mu\nu}$ itself. Briefly, is and why is matter more fundamental[39] than space-time? In contrast to such a position, is the assumption justified that *without* the space-time structure encoded in the metric *no* energy tensor? To bring it to the point, can space-time (and its geometric structure) exist without matter and if yes, what kind of existence could this be? Einstein's starting point was to derive space-time structure from the properties of material systems. However, the theorem before does not exclude the possibility that the energy tensor depends on the metric field too or is completely determined by the metric field. Consequently, the matter fields themselves are derivable from the structure of space-time or the very definition of an energy tensor is determined by space-time structures too. Thus far, the question is not answered definitely, which came first, *either* space-time structure *or* energy tensor. So it is reasonable to ask, is the energy-momentum tensor of matter only dependent on the structure of space-time or even determined by the structure of space-time or both or none? In other words, granddaddies *either* chicken *or* the egg dilemma is revitalized and asking for an innovative and a comprehensive solution and may end up in an Anti-Machian[40] theory. However, this leads us at this point too far afield.

Theorem 3.3 (EINSTEIN'S FIELD EQUATION'S COMPLETELY GEOMETRIZED).
Now, we can derive a completely geometrical form of Einstein's field equations.
CLAIM.
In general, the completely geometrical form of Einstein's field equations is given by

$$\left(S \times g_{\mu v}\right) - \left(\left(\frac{R}{2}\right) \times \left(g_{\mu v}\right)\right) + \left(\Lambda \times g_{\mu v}\right) \equiv \left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) \times g_{\mu v} \quad (86)$$

PROOF BY MODUS PONENS.
If the premise of modus ponens

$$(+1) \equiv (+1) \quad (87)$$

is true, **then** the following conclusion

$$\left(S \times g_{\mu v}\right) - \left(\left(\frac{R}{2}\right) \times \left(g_{\mu v}\right)\right) + \left(\Lambda \times g_{\mu v}\right) \equiv \left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) \times g_{\mu v} \quad (88)$$

is also true, the absence of any technical errors presupposed. The premise

$$(+1) \equiv (+1) \quad (89)$$

is true. Multiplying this premise by the stress-energy momentum tensor of matter, we obtain

$$(+1) \times \left(\left(\frac{8 \times \pi \times \gamma}{c^4}\right) \times T_{\mu v}\right) \equiv (+1) \times \left(\left(\frac{8 \times \pi \times \gamma}{c^4}\right) \times T_{\mu v}\right) \quad (90)$$

or

$$\left(\left(\frac{8 \times \pi \times \gamma}{c^4}\right) \times T_{\mu v}\right) \equiv \left(\left(\frac{8 \times \pi \times \gamma}{c^4}\right) \times T_{\mu v}\right) \quad (91)$$

This equation simplifies according to the theorem before as

$$\left(\left(\frac{8 \times \pi \times \gamma}{c^4}\right) \times T_{\mu v}\right) \equiv \left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) \times g_{\mu v} \quad (92)$$

Einstein's field equations are given as

$$\left(R_{\mu\nu}\right)-\left(\left(\frac{R}{2}\right)\times\left(g_{\mu\nu}\right)\right)+\left(\Lambda\times g_{\mu\nu}\right) \equiv \left(\frac{2\times\pi\times\gamma\times T}{c^{4}}\right)\times g_{\mu\nu} \quad (93)$$

Since $R_{\mu\nu}=S\times g_{\mu\nu}$, we obtain Einstein's field equations completely geometrized as

$$\left(S\times g_{\mu\nu}\right)-\left(\left(\frac{R}{2}\right)\times\left(g_{\mu\nu}\right)\right)+\left(\Lambda\times g_{\mu\nu}\right) \equiv \left(\frac{2\times\pi\times\gamma\times T}{c^{4}}\right)\times g_{\mu\nu} \quad (94)$$

In other words, our conclusion is true.
QUOD ERAT DEMONSTRANDUM.

Theorem 3.4 (THE RICCI TENSOR AND LOCALITY AND NON-LOCALITY).
CLAIM.
In general, the Ricci tensor is determined by a local and non-local part as

$$\left(R_{\mu\nu}\right) \equiv \left(\underline{W}_{\mu\nu}\right)+\left(W_{\mu\nu}\right) \quad (95)$$

PROOF BY MODUS PONENS.
If the premise of modus ponens

$$(+1) \equiv (+1) \quad (96)$$

is true, **then** the following conclusion

$$\left(R_{\mu\nu}\right) \equiv \left(\underline{W}_{\mu\nu}\right)+\left(W_{\mu\nu}\right) \quad (97)$$

is also true, the absence of any technical errors presupposed. The premise

$$(+1) \equiv (+1) \quad (98)$$

is true. Multiplying this premise by the Riemann curvature tensor $R_{kl\mu\nu}$, we obtain

$$(+1)\times\left(R_{kl\mu\nu}\right) \equiv (+1)\times\left(R_{kl\mu\nu}\right) \quad (99)$$

or

$$\left(R_{kl\mu\nu}\right) \equiv \left(R_{kl\mu\nu}\right) \quad (100)$$

Adding zero to this tensor, it is

$$\left(R_{kl\mu\nu}\right)+0 \equiv \left(R_{kl\mu\nu}\right)-W_{kl\mu\nu}+W_{kl\mu\nu} \quad (101)$$

According to our definition, it is

$$\underline{W}_{kl\mu\nu} \equiv \left(R_{kl\mu\nu}\right)-W_{kl\mu\nu} \quad (102)$$

Substituting this relationship into the equation before, we obtain

$$\left(R_{kl\mu\nu}\right) \equiv \left(\underline{W}_{kl\mu\nu}\right) + \left(W_{kl\mu\nu}\right) \tag{103}$$

The *massless, traceless* Weyl's curvature tensor $W_{kl\mu\nu}$ (*the tensor of non-locality*) does not convey any information on how the volume of a certain body changes, but rather how the shape of this body is distorted by tidal forces. In contrast to this, the trace-full massive *anti Weyl's curvature tensor* $\underline{W}_{kl\mu\nu}$ (*the tensor of locality*) convey information on how the volume of a certain body changes, but does not convey information how the shape of this body is distorted. A further manipulation (decomposition) of this equation before yields the following relationship.

$$\left(g^{kl} \times \left(R_{kl\mu\nu}\right)\right) \equiv \left(g^{kl} \times \left(\underline{W}_{kl\mu\nu}\right)\right) + \left(g^{kl} \times \left(W_{kl\mu\nu}\right)\right) \tag{104}$$

which simplifies the relationship as

$$\left(R_{\mu\nu}\right) \equiv \left(\underline{W}_{\mu\nu}\right) + \left(W_{\mu\nu}\right) \tag{105}$$

In other words, our conclusion is true.
QUOD ERAT DEMONSTRANDUM.

The Riemann tensor $R_{kl\mu\nu}$ describes among other the curvature of spacetime. However, due to the Einstein equations and in the absence of sources, the trace part of the Riemann curvature tensor will vanish. In particular, even in the absence of any sources, there can be small variations of curvature (i.e. gravitational waves) or a non-zero curvature of space time. In other words, under these circumstances, the Weyl curvature tensor $W_{kl\mu\nu}$ as the trace-free part of the Riemann curvature tensor $R_{kl\mu\nu}$ can still be non-zero. In addition to this, electromagnetic waves propagating in vacuum can be described by the source-free Maxwell equations without specifying anything about charges or currents that might have produced them. In point of fact, changes in the gravitational field propagate as gravitational waves. The Weyl tensor $W_{\mu\nu}$, and the role it plays in describing gravitational waves is related to the 3-Cotton[41]-York[42] tensor too which is rarely mentioned in this connection. The 3-Cotton-York tensor like Weyl's co-variant second rank tensor $W_{\mu\nu}$ is not locally determined by a matter field and is to some extent suitable[43] for describing gravitational waves in the 1+3 formalism. It is necessary to note that *Weyl's tensor*, denoted as $W_{\mu\nu}$, comes from the contraction of the *Weyl's*[19] *curvature tensor* $W_{kl\mu\nu}$. The so called *anti Weyl's tensor*, denoted as $\underline{W}_{\mu\nu}$, comes from the contraction of *anti Weyl's curvature tensor* $\underline{W}_{kl\mu\nu}$ and is of use to approach to the description of non-locality in terms of general theory of relativity. Quantum theory is more or less kinematically nonlocal, while Einstein's theory of relativity (including relativistic quantum field theory) requires something like a dynamical locality ("Einstein locality"). One can hardly help thinking that quantum non-locality cannot be reconciled with Einstein locality. Nonetheless, might there be some circumstances which could have led to a change of mind? Under which conditions does general relativity leads to non-local[44] effects in the matter sector and can such non-local effects can be described somehow? Another possible point of criticism is the unified field theory program. In this respect and due to the considerations being given before let us consider the following. Can and how can the for basic fields of nature be described from the point of view of non-locality? *Table 2* may provide a preliminary overview of the issue mentioned and the definitions of the four basic fields of nature under these conditions

		Locality		
		Yes	No	
Momentum	Yes	$\mathbf{a_{\mu\nu}}$	$\mathbf{b_{\mu\nu}}$	$E \times g_{\mu\nu}$
	No	$\mathbf{x_{\mu\nu}}$	$\mathbf{y_{\mu\nu}}$	$\underline{t} \times g_{\mu\nu}$
		$\underline{W}_{\mu\nu}$	$W_{\mu\nu}$	$S \times g_{\mu\nu}$

Table 2. Four basic fields of nature and non-locality

while for preliminary purposes, *the Weyl’s tensor $W_{\mu\nu}$ is used to describe non-locality*. Furthermore, in this context and only for the sake of the argument it is assumed that $(x_{\mu\nu})+(y_{\mu\nu}) =((R/2)\times g_{\mu\nu})-(\Lambda \times g_{\mu\nu})$ and that $(x_{\mu\nu}) = (\underline{W}_{\mu\nu})-(a_{\mu\nu})$ and that $(y_{\mu\nu}) = (W_{\mu\nu})-(y_{\mu\nu})$. Under these conditions, the tensor $y_{\mu\nu}$ would to be determined as

$$y_{\mu\nu} \equiv W_{\mu\nu} - \left(\left(\frac{1}{4 \times 4 \times \pi}\right) \times \left(\left(F_{\mu c} \times F^{\mu c}\right) - \left(F_{de} \times F^{de}\right) \right) \right) \times g_{\mu\nu} \tag{106}$$

What kind of a particle can be ascribed to the field $y_{\mu\nu}$. Pert like ever it is difficult suppress the remark: none. Something, even if mathematically correct, need not to be epistemologically valuable too. Another consequence of such an approach to unified field theories would be the need to accept the following form of the tensor $x_{\mu\nu}$.

$$x_{\mu\nu} \equiv \underline{W}_{\mu\nu} - \left(\left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) \times g_{\mu\nu} - \left(\left(\frac{1}{4 \times 4 \times \pi}\right) \times \left(\left(F_{\mu c} \times F^{\mu c}\right) - \left(F_{de} \times F^{de}\right) \right) \right) \times g_{\mu\nu} \right) \tag{107}$$

which is again mathematically correct but is still not very convincing. We still may not have the final word on the relationship between general relativity and non-locality, but in any case, it is possible to approach even to the solution of this problem.

Theorem 3.5 (EINSTEIN'S FIELD EQUATION'S AND WEYL'S CURVATURE).
A reformulation of Einstein's field equations in much greater detail in terms of Weyl's curvature tensor highlights the path of general relativity to non-locality more than the original one field equations.
CLAIM.
In general, locality and non-locality int terms of Einstein's field equations are given as

$$\left(\underline{W}_{\mu\nu}\right) - \left(\left(\frac{R}{2}\right) \times \left(g_{\mu\nu}\right)\right) + \left(\Lambda \times g_{\mu\nu}\right) + \left(W_{\mu\nu}\right) \equiv \left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) \times g_{\mu\nu} \quad (108)$$

PROOF BY MODUS PONENS.
If the premise of modus ponens

$$(+1) \equiv (+1) \quad (109)$$

is true, **then** the following conclusion

$$\left(\underline{W}_{\mu\nu}\right) - \left(\left(\frac{R}{2}\right) \times \left(g_{\mu\nu}\right)\right) + \left(\Lambda \times g_{\mu\nu}\right) + \left(W_{\mu\nu}\right) \equiv \left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) \times g_{\mu\nu} \quad (110)$$

is also true, the absence of any technical errors presupposed. The premise

$$(+1) \equiv (+1) \quad (111)$$

is true. Multiplying this premise by the stress-energy momentum tensor of matter, we obtain

$$(+1) \times \left(\left(\frac{8 \times \pi \times \gamma}{c^4}\right) \times T_{\mu\nu}\right) \equiv (+1) \times \left(\left(\frac{8 \times \pi \times \gamma}{c^4}\right) \times T_{\mu\nu}\right) \quad (112)$$

or

$$\left(\left(\frac{8 \times \pi \times \gamma}{c^4}\right) \times T_{\mu\nu}\right) \equiv \left(\left(\frac{8 \times \pi \times \gamma}{c^4}\right) \times T_{\mu\nu}\right) \quad (113)$$

This equation simplifies according to the theorem before as

$$\left(\left(\frac{8 \times \pi \times \gamma}{c^4}\right) \times T_{\mu\nu}\right) \equiv \left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) \times g_{\mu\nu} \quad (114)$$

Einstein's field equations are given as

$$\left(R_{\mu\nu}\right) - \left(\left(\frac{R}{2}\right) \times \left(g_{\mu\nu}\right)\right) + \left(\Lambda \times g_{\mu\nu}\right) \equiv \left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) \times g_{\mu\nu} \quad (115)$$

As found before, it is $R_{\mu\nu} = W_{\mu\nu} + \underline{W}_{\mu\nu}$. Einstein's field equations in terms of Weyl's tensor follow as

$$\left(\left(\underline{W}_{\mu\nu}\right) + \left(W_{\mu\nu}\right)\right) - \left(\left(\frac{R}{2}\right) \times \left(g_{\mu\nu}\right)\right) + \left(\Lambda \times g_{\mu\nu}\right) \equiv \left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) \times g_{\mu\nu} \quad (116)$$

or as

$$\left(\underline{W}_{\mu\nu}\right) - \left(\left(\frac{R}{2}\right) \times \left(g_{\mu\nu}\right)\right) + \left(\Lambda \times g_{\mu\nu}\right) + \left(W_{\mu\nu}\right) \equiv \left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) \times g_{\mu\nu} \quad (117)$$

In other words, our conclusion is (mathematically) true.

QUOD ERAT DEMONSTRANDUM.

However, the properties of the Weyl tensor $W_{\mu\nu}$ demand that its contraction vanishes[22] or it is

$$\left(g^{kl} \times \left(W_{kl\mu\nu}\right)\right) \equiv \left(W_{\mu\nu}\right) \equiv 0 \quad (118)$$

Thus far, even if this tensor is formally present inside the famous Einstein equation, the question is justified, how much information does Weyl tensor $W_{\mu\nu}$ contain (namely the information as regards the gravitational field invacuum).

Theorem 3.6 (THE RICCI TENSOR AND LOCALITY AND NON-LOCALITY).

CLAIM.

In the following let $L_{\mu\nu}$ denote covariant second rank tensor locality, let $\underline{L}_{\mu\nu}$ denote the covariant second rank tensor of non-locality. In general, the Ricci tensor is determined by a local and non-local part as

$$\left(R_{\mu\nu}\right) \equiv \left(\underline{L}_{\mu\nu}\right) + \left(L_{\mu\nu}\right) \quad (119)$$

PROOF BY MODUS PONENS.

If the premise of modus ponens

$$(+1) \equiv (+1) \quad (120)$$

is true, **then** the following conclusion

$$\left(R_{\mu\nu}\right) \equiv \left(\underline{L}_{\mu\nu}\right) + \left(L_{\mu\nu}\right) \quad (121)$$

is also true, the absence of any technical errors presupposed. The premise

$$(+1) \equiv (+1) \quad (122)$$

is true. Multiplying this premise by the Riemann curvature tensor $R_{kl\mu\nu}$, we obtain

$$(+1) \times \left(R_{kl\mu\nu}\right) \equiv (+1) \times \left(R_{kl\mu\nu}\right) \quad (123)$$

or

$$\left(R_{kl\mu\nu}\right) \equiv \left(R_{kl\mu\nu}\right) \quad (124)$$

Adding zero to this tensor, it is

$$\left(R_{kl\mu\nu}\right)+0 \equiv \left(R_{kl\mu\nu}\right)-L_{kl\mu\nu}+L_{kl\mu\nu} \tag{125}$$

while $L_{kl\mu\nu}$ may denote the completely local part of Riemann curvature tensor $R_{kl\mu\nu}$. In the following, we define

$$\underline{L}_{kl\mu\nu} \equiv \left(R_{kl\mu\nu}\right)-L_{kl\mu\nu} \tag{126}$$

while $\underline{L}_{kl\mu\nu}$ may denote *the completely non-local part of Riemann curvature tensor* $R_{kl\mu\nu}$. Substituting this relationship into the equation before, it is

$$\left(R_{kl\mu\nu}\right) \equiv \left(\underline{L}_{kl\mu\nu}\right)+\left(L_{kl\mu\nu}\right) \tag{127}$$

It is necessary to note that *the non-local part* ($\underline{L}_{kl\mu\nu}$) *of Riemann curvature tensor* ($R_{kl\mu\nu}$) need not to be completely identical with Weyl's curvature tensor ($W_{kl\mu\nu}$). A further manipulation (decomposition) of this equation before yields the following relationship.

$$\left(g^{kl}\times\left(R_{kl\mu\nu}\right)\right) \equiv \left(g^{kl}\times\left(\underline{L}_{kl\mu\nu}\right)\right)+\left(g^{kl}\times\left(L_{kl\mu\nu}\right)\right) \tag{128}$$

which simplifies the relationship as

$$\left(R_{\mu\nu}\right) \equiv \left(\underline{L}_{\mu\nu}\right)+\left(L_{\mu\nu}\right) \tag{129}$$

In other words, our conclusion is true.
QUOD ERAT DEMONSTRANDUM.

The thought is unavoidable and it is difficult to suppress the possible consequences. In order to enable a logically consistent discussion about locality and non-locality from the point of view of general relativity it is possible and necessary to decompose Riemannian curvature tensor in an appropriate way. Finally, the need becomes clear, what could be the concrete geometrical structure of such tensors?

Theorem 3.7 (THE TENSOR OF LOCALITY AND OF NON-LOCALITY).
How local is an electromagnetic wave or an electromagnetic field? How is a gravitational wave and a gravitational field?
CLAIM.
In the following let $L_{\mu\nu}$ denote covariant second rank tensor locality, let $\underline{L}_{\mu\nu}$ denote the covariant second rank tensor of non-locality. In general, the tensor of non-locality is determined as

$$\underline{L}_{\mu\nu} \equiv \left(\left(R_{\mu\nu}\right)-\left(a_{\mu\nu}\right)\right) \tag{130}$$

PROOF BY MODUS PONENS.
If the premise of modus ponens

$$(+1) \equiv (+1) \tag{131}$$

is true, **then** the following conclusion

$$\underline{L}_{\mu\nu} \equiv \left(\left(R_{\mu\nu}\right) - \left(a_{\mu\nu}\right)\right) \tag{132}$$

is also true, the absence of any technical errors presupposed. The premise

$$(+1) \equiv (+1) \tag{133}$$

is true. Multiplying this premise by the Ricci tensor $R_{\mu\nu}$, we obtain

$$(+1) \times \left(R_{\mu\nu}\right) \equiv (+1) \times \left(R_{\mu\nu}\right) \tag{134}$$

or

$$\left(R_{\mu\nu}\right) \equiv \left(R_{\mu\nu}\right) \tag{135}$$

According to our definition before, this equation changes to

$$\left(a_{\mu\nu}\right) + \left(b_{\mu\nu}\right) + \left(c_{\mu\nu}\right) + \left(d_{\mu\nu}\right) \equiv \left(R_{\mu\nu}\right) \tag{136}$$

In our understanding, we define the tensor of non-locality $\underline{L}_{\mu\nu}$ as

$$\left(b_{\mu\nu}\right) + \left(c_{\mu\nu}\right) + \left(d_{\mu\nu}\right) \equiv \left(\underline{L}_{\mu\nu}\right) \tag{137}$$

It follows that,

$$\underline{L}_{\mu\nu} \equiv \left(b_{\mu\nu}\right) + \left(c_{\mu\nu}\right) + \left(d_{\mu\nu}\right) \equiv \left(\left(R_{\mu\nu}\right) - \left(a_{\mu\nu}\right)\right) \tag{138}$$

In other words, our conclusion is true.
QUOD ERAT DEMONSTRANDUM.

In more detail. The tensor of non locality $\underline{L}_{\mu\nu}$ is determined as

$$\underline{L}_{\mu\nu} \equiv \left(S - \left(\left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) - \left(\left(\frac{1}{4 \times 4 \times \pi}\right) \times \left(\left(F_{\mu c} \times F^{\mu c}\right) - \left(F_{de} \times F^{de}\right)\right) \right) \right) \right) \times g_{\mu\nu} \tag{139}$$

Logically, the tensor of locality $L_{\mu\nu}$ is determined as

$$\left(L_{\mu\nu}\right) \equiv \left(R_{\mu\nu}\right) - \left(b_{\mu\nu}\right) - \left(c_{\mu\nu}\right) - \left(d_{\mu\nu}\right) \equiv \left(R_{\mu\nu}\right) - \left(\underline{L}_{\mu\nu}\right) \quad (140)$$

It is of course a matter of further research, whether such an approach to the issue of locality and non-locality can lead to the desired solution of the problem of locality and non-locality form the point of view of general theory of relativity. Considering these tensors, Einstein's field equation changes too

$$\left(L_{\mu\nu}\right) - \left(\left(\frac{R}{2}\right) \times \left(g_{\mu\nu}\right)\right) + \left(\Lambda \times g_{\mu\nu}\right) + \left(\underline{L}_{\mu\nu}\right) \equiv \left(\frac{2 \times \pi \times \gamma \times T}{c^4}\right) \times g_{\mu\nu} \quad (141)$$

Theorem 3.8 (WEYL'S TENSOR AND NON-LOCALITY).
CLAIM.
Weyl's curvature tensor ($W_{kl\mu\nu}$) is a very important and determining part of the non-locality curvature tensor ($\underline{L}_{kl\mu\nu}$). In general, it is

$$\left(\underline{L}_{kl\mu\nu}\right) \equiv \left(W_{kl\mu\nu}\right) + \left(Z_{kl\mu\nu}\right) \quad (142)$$

PROOF BY MODUS PONENS.
If the premise of modus ponens

$$(+1) \equiv (+1) \quad (143)$$

is true, **then** the following conclusion

$$\left(\underline{L}_{kl\mu\nu}\right) \equiv \left(W_{kl\mu\nu}\right) + \left(Z_{kl\mu\nu}\right) \quad (144)$$

is also true, the absence of any technical errors presupposed. The premise

$$(+1) \equiv (+1) \quad (145)$$

is true. Multiplying this premise by the Riemann curvature tensor $R_{kl\mu\nu}$, we obtain

$$(+1) \times \left(R_{kl\mu\nu}\right) \equiv (+1) \times \left(R_{kl\mu\nu}\right) \quad (146)$$

or

$$\left(R_{kl\mu\nu}\right) \equiv \left(R_{kl\mu\nu}\right) \quad (147)$$

Adding zero to this tensor, it is

$$(R_{kl\mu\nu}) + 0 \equiv (R_{kl\mu\nu}) - L_{kl\mu\nu} + L_{kl\mu\nu} \tag{148}$$

while $L_{kl\mu\nu}$ may denote the completely local part of Riemann curvature tensor $R_{kl\mu\nu}$. As defined before, it is

$$\underline{L}_{kl\mu\nu} \equiv (R_{kl\mu\nu}) - L_{kl\mu\nu} \tag{149}$$

while $\underline{L}_{kl\mu\nu}$ denote *the completely non-local part of Riemann curvature tensor* $R_{kl\mu\nu}$. Substituting this relationship into the equation before, we obtain

$$(R_{kl\mu\nu}) \equiv (\underline{L}_{kl\mu\nu}) + (L_{kl\mu\nu}) \tag{150}$$

However, the *Riemann curvature tensor* $R_{kl\mu\nu}$ is determined by the Weyl's curvature tensor ($W_{kl\mu\nu}$). In other words, the following equation is valid too:

$$(L_{kl\mu\nu}) + (\underline{L}_{kl\mu\nu}) \equiv (W_{kl\mu\nu}) + (\underline{W}_{kl\mu\nu}) \tag{151}$$

Rearranging equation, we obtain

$$(\underline{L}_{kl\mu\nu}) \equiv (W_{kl\mu\nu}) + (\underline{W}_{kl\mu\nu}) - (L_{kl\mu\nu}) \tag{152}$$

According to our definition before, this equation simplifies as

$$(\underline{L}_{kl\mu\nu}) \equiv (W_{kl\mu\nu}) + (Z_{kl\mu\nu}) \tag{153}$$

In other words, our conclusion is true.
QUOD ERAT DEMONSTRANDUM.

Theorem 3.9 (THE IDENTITY AND DIFFERENCE BETWEEN WEYL'S TENSOR AND THE TENSOR OF NON-LOCALITY).
CLAIM.
Under certain circumstances, Weyl's curvature tensor ($W_{kl\mu\nu}$) is identical with the non-locality curvature tensor ($\underline{L}_{kl\mu\nu}$). The identity of Weyl's curvature tensor ($W_{kl\mu\nu}$) and the non-locality curvature tensor is given only under conditions where

$$(Z_{kl\mu\nu}) \equiv 0 \tag{154}$$

PROOF BY MODUS PONENS.
If the premise of modus ponens

$$(+1) \equiv (+1) \tag{155}$$

is true, **then** the following conclusion

$$\left(Z_{kl\mu v}\right) \equiv 0 \tag{156}$$

is also true, the absence of any technical errors presupposed. The premise

$$(+1) \equiv (+1) \tag{157}$$

is true. Multiplying this premise by the Riemann curvature tensor, we obtain

$$(+1) \times \left(\underline{L}_{kl\mu v}\right) \equiv (+1) \times \left(\underline{L}_{kl\mu v}\right) \tag{158}$$

or

$$\left(\underline{L}_{kl\mu v}\right) \equiv \left(\underline{L}_{kl\mu v}\right) \tag{159}$$

According to the theorem before, it is equally

$$\left(\underline{L}_{kl\mu v}\right) \equiv \left(W_{kl\mu v}\right) + \left(Z_{kl\mu v}\right) \tag{160}$$

Under conditions, where the tensor vanish $Z_{kl\mu\nu}$, i.e. where $Z_{kl\mu\nu} = 0$, it is

$$\left(\underline{L}_{kl\mu v}\right) \equiv \left(W_{kl\mu v}\right) + 0 \tag{161}$$

Only under circumstances where

$$\left(Z_{kl\mu v}\right) \equiv 0 \tag{162}$$

it is

$$\left(\underline{L}_{kl\mu v}\right) \equiv \left(W_{kl\mu v}\right) \tag{163}$$

but not in general. In other words, our conclusion is true.
QUOD ERAT DEMONSTRANDUM.

Weyl's curvature tensor is not completely identical with a tensor of non-locality but contributes to the same essentially. The following table 3 may provide an overview.

		Weyl's curvature		
		Yes	No	
Locality	Yes	$\mathbf{a}_{kl\mu\nu}$	$\mathbf{b}_{kl\mu\nu}$	$L_{kl\mu\nu}$
	No	$\mathbf{c}_{kl\mu\nu}$	$\mathbf{d}_{kl\mu\nu}$	$\underline{L}_{kl\mu\nu}$
		$W_{kl\mu\nu}$	$\underline{W}_{kl\mu\nu}$	$R_{kl\mu\nu}$

Table 3. Locality and non-locality

5. Discussion

Einstein's long lasting unified field theory program[45] was at the end completely in vain but still justified in every conceivable way. However, any successful enterprise to geometrize all fundamental interactions of nature should provide in the same respect *a completely geometrized*[8] *theory of relativity* too and will simplify the work of at least view scientists. In spite of the fact that Einstein's general theory of relativity (GTR) is an excellent theory of gravity which is tested to a very high precision and which works extremely well at large distances, in the infrared (IR) regime et cetera, it is more than quite surprising to be confronted with claims that GTR breaks down at short distances, in smalltime scales or in the ultraviolet (UV) regime et cetera. In the region of non-locality, the Ricci tensor and the Ricci scalar are not[46] vanishing for sure. It is known that *the Ricci tensor* determines the contribution to the space-time curvature from ***the local sources*** with energy-momentum tensor of matter/energy $T_{\mu\nu}$. In contrast to this, *the Weyl tensor* gives the contribution due to ***the non local sources***. The Weyl curvature tensor is the traceless part of the Riemann curvature tensor. Meanwhile, there is some evidence that the *Weyl tensor* vanishes[46] especially at short distances. In other words, in the region of *non-locality*, the spacetime metric becomes conformally flat. As a consequence, a non-local region may theoretically be approached by a conformally flat manifold. However, Weyl's tensor $W_{\mu\nu}$ is part of the tensor on non-locality tensor $\underline{L}_{\mu\nu}$.

5. Conclusion

Weyl's curvature tensor ($W_{kl\mu\nu}$) is not completely identical with a non-locality curvature tensor.

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References

1. Newton I. Philosophiae naturalis principia mathematica [Internet]. Londini: Jussu Societatis Regiae ac Typis Josephi Streater. Prostat apud plures bibliopolas; 1687 [cited 2019 Feb 12]. Available from: https://doi.org/10.5479/sil.52126.39088015628399
2. Einstein A. Zur Elektrodynamik bewegter Körper. Ann Phys [Internet]. 1905 [cited 2019 Feb 12];322(10):891–921. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1002/andp.19053221004
3. Barukčić I. The Equivalence of Time and Gravitational Field. Phys Procedia. 2011 Jan 1;22:56–62.
4. Einstein A. Die Feldgleichungen der Gravitation. Sitzungsberichte K Preußischen Akad Wiss Berl Seite 844-847 [Internet]. 1915 [cited 2019 Feb 12]; Available from: http://adsabs.harvard.edu/abs/1915SPAW.......844E
5. Einstein A. Die Grundlage der allgemeinen Relativitätstheorie. Ann Phys [Internet]. 1916 [cited 2019 Mar 7];354:769–822. Available from: http://adsabs.harvard.edu/abs/1916AnP...354..769E
6. Einstein A. Kosmologische Betrachtungen zur allgemeinen Relativitätstheorie. Sitzungsberichte K Preußischen Akad Wiss Berl Seite 142-152 [Internet]. 1917 [cited 2019 Feb 12]; Available from: http://adsabs.harvard.edu/abs/1917SPAW.......142E
7. Goenner HFM. On the History of Unified Field Theories. Living Rev Relativ [Internet]. 2004 [cited 2019 Dec 18];7(1). Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5256024/
8. Einstein A. On the Generalized Theory of Gravitation. Sci Am [Internet]. 1950 Apr 1 [cited 2019 Feb 12];182:13–7. Available from: http://adsabs.harvard.edu/abs/1950SciAm.182d..13E
9. Einstein A, de Sitter W. On the Relation between the Expansion and the Mean Density of the Universe. Proc Natl Acad Sci U S A [Internet]. 1932 Mar [cited 2019 Feb 12];18(3):213–4. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1076193/
10. Thmoson J. Joint eclipse meeting of the Royal Society and the Royal Astronomical Society. The Observatory [Internet]. 1919;42(545):89–398. Available from: http://articles.adsabs.harvard.edu/cgi-bin/t2png?bg=%23FFFFFF&/seri/Obs../0042/600/0000389.000&db_key=AST&bits=4&res=100&filetype=.gif
11. Ricci MMG, Levi-Civita T. Méthodes de calcul différentiel absolu et leurs applications. Math Ann [Internet]. 1900 Mar 1 [cited 2020 May 13];54(1):125–201. Available from: https://doi.org/10.1007/BF01454201
12. Barukčić I. Anti Einstein – Refutation of Einstein's General Theory of Relativity. Int J Appl Phys Math. 2015;5(1):18–28.
13. Lovelock D. The Einstein Tensor and Its Generalizations. J Math Phys [Internet]. 1971 Mar 1 [cited 2020 Jun 12];12(3):498–501. Available from: https://aip.scitation.org/doi/10.1063/1.1665613
14. Barukčić I. Unified Field Theory. J Appl Math Phys. 2016 Jan 1;04(08):1379–438.

15. Barukčić I. Anti Newton — Refutation of the Constancy of Newton's Gravitational Constant Big G. Int J Appl Phys Math. 2015;5(2):126–36.
16. Barukčić I. Newton's Gravitational Constant Big G Is Not a Constant. J Mod Phys. 2016;07(06):510–22.
17. Barukčić I. Anti Newton - Refutation Of The Constancy Of Newton's Gravitatkional Constant G: List of Abstracts. Quantum Theory Probl Adv QTPA 2014 Växjö Swed June 9-12 2014. 2014 Jan 1;63.
18. Barukčić I. Anti Newton - Refutation Of The Constancy Of Newton's Gravitatkional Constant G: Conferences Programm. 2rd Int Conf Phys Sci Technol ICPST 2016 January 7-8 2015 Dohar Qatar. 2015 Jan 1;
19. Weyl H. Reine Infinitesimalgeometrie. Math Z [Internet]. 1918 Sep 1 [cited 2020 Jun 12];2(3):384–411. Available from: https://doi.org/10.1007/BF01199420
20. Danehkar A. On the significance of the weyl curvature in a relativistic cosmological model. Mod Phys Lett A [Internet]. 2009 Dec 14 [cited 2020 Jun 12];24(38):3113–27. Available from: https://www.worldscientific.com/doi/abs/10.1142/S0217732309032046
21. Einstein A. Über Gravitationswellen. Sitzungsberichte K Preußischen Akad Wiss Berl Seite 154-167 [Internet]. 1918 [cited 2019 Mar 7]; Available from: http://adsabs.harvard.edu/abs/1918SPAW.......154E
22. Moulin F. Generalization of Einstein's gravitational field equations. Eur Phys J C [Internet]. 2017 Dec [cited 2020 Jun 12];77(12). Available from: http://link.springer.com/10.1140/epjc/s10052-017-5452-y
23. Barukčić I. The Physical Meaning of the Wave Function. J Appl Math Phys. 2016 Jan 1;04(06):988–1023.
24. Einstein A. The meaning of relativity. Four lectures delivered at Princeton University, May, 1921. Princeton: Princeton University Press; 1923.
25. Laue M. Zur Dynamik der Relativitätstheorie. Ann Phys [Internet]. 1911 [cited 2020 May 16];340(8):524–42. Available from: https://onlinelibrary.wiley.com/doi/pdf/10.1002/andp.19113400808
26. Einstein A, Grossmann M. Entwurf einer verallgemeinerten Relativitätstheorie und einer Theorie der Gravitation: Physikalischer Teil von Albert Einstein. Mathematischer Teil von Marcel Grossmann. Leipzig: B. G. Teubner; 1913. 38 p.
27. Kay DC. Schaum's outline of theory and problems of tensor calculus. New York: McGraw-Hill; 1988. 228 p. (Schaum's outline series. Schaum's outline series in mathematics).
28. Hilbert D. Axiomatisches Denken. Math Ann [Internet]. 1917 Dec 1 [cited 2019 May 30];78(1):405–15. Available from: https://doi.org/10.1007/BF01457115
29. Easwaran K. The Role of Axioms in Mathematics. Erkenntnis [Internet]. 2008 May 1 [cited 2019 Dec 8];68(3):381–91. Available from: https://doi.org/10.1007/s10670-008-9106-1
30. Einstein A. Induktion and Deduktion in der Physik. Berliner Tageblatt and Handelszeitung [Internet]. 1919 Dec 25;Suppl. 4. Available from: https://einsteinpapers.press.princeton.edu/vol7-trans/124
31. Leibniz GW Freiherr von. Oeuvres philosophiques latines & françoises de feu Mr. de Leibnitz [Internet]. Amsterdam (NL): Chez Jean Schreuder; 1765 [cited 2019 Jan 16]. Available from: https://archive.org/details/oeuvresphilosoph00leibuoft/page/n9
32. Barukčić I. Aristotle's law of contradiction and Einstein's special theory of relativity. J Drug Deliv Ther [Internet]. 2019 Mar 15 [cited 2019 Mar 16];9(2):125–43. Available from: http://jddtonline.info/index.php/jddt/article/view/2389

33. Spinoza BD. Opera quae supersunt omnia / iterum edenda curavit, praefationes, vitam auctoris, nec non notitias, quae ad historiam scriptorum pertinent [Internet]. Heinrich Eberhard Gottlob Paulus. Vol. 2 Tomi. Ienae: In Bibliopolio Academico: In Bibliopolio Academico; 1802 [cited 2019 Feb 28]. Available from: http://www.e-rara.ch/doi/10.3931/e-rara-14505
34. Boole G. An investigation of the laws of thought, on which are founded mathematical theories of logic and probabilities [Internet]. New York, Dover; 1854 [cited 2019 Jan 16]. 441 p. Available from: http://archive.org/details/bub_gb_DqwAAAAAcAAJ
35. Barukčić I. Classical Logic And The Division By Zero. Int J Math Trends Technol IJMTT [Internet]. 2019 [cited 2019 Sep 5];65(7):31–73. Available from: http://www.ijmttjournal.org/archive/ijmtt-v65i8p506
36. Barukčić I. The Geometrization of the Electromagnetic Field. J Appl Math Phys. 2016;04(12):2135–71.
37. Witten L. Geometry of Gravitation and Electromagnetism. Phys Rev [Internet]. 1959 Jul 1 [cited 2020 Jun 13];115(1):206–14. Available from: https://link.aps.org/doi/10.1103/PhysRev.115.206
38. Olkhov OA. New Approach to Geometrization of Electromagnetic Field. Am J Phys Appl [Internet]. 2015 Dec 31 [cited 2020 Jun 13];3(6):221. Available from: http://www.sciencepublishinggroup.com/journal/paperinfo.aspx?journalid=622&doi=10.11648/j.ajpa.20150306.16
39. Lehmkuhl D. Mass-Energy-Momentum: Only there Because of Spacetime? Br J Philos Sci [Internet]. 2011 Sep 1 [cited 2020 May 16];62(3):453–88. Available from: https://academic.oup.com/bjps/article-lookup/doi/10.1093/bjps/axr003
40. Lehmkuhl D. Why Einstein did not believe that general relativity geometrizes gravity. Stud Hist Philos Sci Part B Stud Hist Philos Mod Phys [Internet]. 2014 May 1 [cited 2019 Jul 14];46:316–26. Available from: http://www.sciencedirect.com/science/article/pii/S1355219813000695
41. Cotton É. Sur les variétés à trois dimensions. Ann Fac Sci Toulouse [Internet]. 1899 [cited 2020 Jun 15];1(4):385–438. Available from: https://web.archive.org/web/20071010003140/http://www.numdam.org/numdam-bin/fitem?id=AFST_1899_2_1_4_385_0
42. York JW. Role of Conformal Three-Geometry in the Dynamics of Gravitation. Phys Rev Lett [Internet]. 1972 Apr 17 [cited 2020 Jun 15];28(16):1082–5. Available from: https://link.aps.org/doi/10.1103/PhysRevLett.28.1082
43. Osano B. The Weyl curvature tensor, Cotton–York tensor and gravitational waves: A covariant consideration. Int J Mod Phys D [Internet]. 2017 Nov 7 [cited 2020 Jun 15];27(03):1850021. Available from: https://www.worldscientific.com/doi/10.1142/S0218271818500219
44. Calmet X, Croon D, Fritz C. Non-locality in quantum field theory due to general relativity. Eur Phys J C [Internet]. 2015 Dec 19 [cited 2020 Jun 15];75(12):605. Available from: https://doi.org/10.1140/epjc/s10052-015-3838-2
45. Einstein A. Einheitliche Feldtheorie von Gravitation und Elektrizität. Preuss Akad Wiss Phys-Math Kl Sitzungsberichte [Internet]. 1925 [cited 2020 May 16];414–419. Available from: https://onlinelibrary.wiley.com/doi/pdf/10.1002/3527608958.ch30

46. Buoninfante L, Koshelev AS, Lambiase G, Mazumdar A. Classical properties of non-local, ghost- and singularity-free gravity. J Cosmol Astropart Phys [Internet]. 2018 Sep [cited 2020 Jun 14];2018(09):034–034. Available from: https://doi.org/10.1088%2F1475-7516%2F2018%2F09%2F034

