A
General Relativistic
Matter Structure Theory
(MST)

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Abstract

Based on a general relativistic bivector formulation of source-free Maxwell equations, we show that a four-dimensional theory can be developed, which describes the structure of matter in the quantum range as well as in the macroscopic range up to cosmological scale. Particles are represented as wave equations (energy density distributions) on cosmological scale in Riemannian spacetime. Thus, concrete metrics for particles can be calculated.

1. Introduction

So far, attempts have been made to unify gravity and electromagnetism, for example, based on non-symmetric metrics in modified theories of relativity, or on a higher-dimensional base such as string theory on far more than 4 dimensions.

All these theories have one in common, they are mathematically complicated, and precise solutions that would explain the structure of matter and a clear unification of gravity and electromagnetism have not yet been found.

In contrast to that, we will develop a theory based on classical general relativity in bi-vectors of source-free Maxwell equations in Riemannian spacetime, which will lead to a simpler unification.

Why do we choose such an approach?

All particle decays finally end in stable (anti)electrons, (anti)protons, photons, and/or (anti)neutrinos and matter-antimatter annihilations stabile particles (e^+e^- and $p\bar{p}$) end finally in photons. Therefore, it seems to be plausible that all elementary particles are somehow built of photons and/or neutrinos. Since photons are free particles with zero rest mass, massive particles must consequently be self-bound energies out of photons from this point of view.

An objective contemplation of Einstein's field equation (EFE) reveals that its obvious mathematical form constitutes the spacetime structure G_{ab} equivalently to the energy density structure T_{ab}.

$$G_{ab} \sim T_{ab}$$

This means that every particle, as well as every more extended material structure with non-zero energy, must simultaneously have a spacetime structure.

We explicitly note here that the separation of matter and spacetime structure in classical general relativity leads to singularities. See, for example, the Schwarzschild metric with the vacuum approach outside the spherical mass with $R_{mn} = 0$. This separation should only be justified as an approximation or simplification for weak gravitational fields in the macroscopic range as of our solar system.

According to the argument of classical quantum mechanics, meaning, due to an unsharp probability density distribution of particles in space, a sharp spatial separation between vacuum and matter is unjustified as well.

We therefore assume in MST infinitely, or more precise, cosmologically extended, continuously differentiable energy density distributions of matter, which should not generate any singularities.

A spatially extended photon with an extremely high energy density, occurring in the subatomic range, where it has the highest probability of being detected, can generate a strong local spacetime distortion. Within this distortion, the photon may become trapped through corresponding interactions and can structure into a particle by self-binding. Furthermore, such a strong local spacetime distortion creating stable particles should fundamentally explain the various types of interactions.

This is the fundamental model perception of particles in MST.

The Copenhagen interpretation of quantum mechanics describes particles as point-like objects with intrinsic physical properties that may be located in space and time with a certain indetermined probability. This interpretation is clearly based on object-oriented or point-like thinking. By experience, we perceive all objects as spatially limited. Thus, we encounter the wave-particle duality in physics, since it was discovered that particles in subatomic range behave as waves. But, at the same time, we do not abandon a space limited object-oriented thinking about particles and extended objects in the macroscopic world.

The above considerations imply the necessity to regard all particles fundamentally as waves, which represent energy density distributions extended throughout the cosmos, with extreme energy density peaks in local subatomic range.

Based on this perspective, we construct the MST on the following three principles:

1) **Matter-Spacetime Equivalence:**

   A) We understand **matter as collective term for energy and mass**, where mass is self-bound, structured energy distribution. In the mathematical sense of the EFE, spacetime is inseparable from the energy density distribution of matter. Matter can therefore always be described by four-dimensional, continuously differentiable spacetime manifolds of Riemannian geometry.

   B) **Particles are wave functions on cosmological scale**, i.e. fundamental building blocks of matter, with continuously, constantly differentiable energy density distributions. Therefore, we abandon in MST the Copenhagen interpretation of quantum mechanics, which is based on the probability density distribution of point-like particles.

2) **Basic building blocks of matter are photons and neutrinos.:**

   Photons are the fundamental building blocks of matter. As all decays and annihilations finally end in photons and neutrinos, and thus, both must have the same physical fundamental base.

3) **Cosmological propagation of particles:**

   Particles have a cosmological extent as per the matter-spacetime equivalence principle. According to the theory of relativity, their energy propagates at the speed of light throughout spacetime. Information or quantum states, that are not associated with energy transport, propagate instantaneously within the particles (see quantum entanglement).

2. Formulation of the MST

2.1 Einstein´s field equation for electromagnetic null-fields

Using the principles outlined above, we formulate fundamental equations of the MST based on general relativity, specifically on Einstein's field equation (EFE), where the stress-energy tensor represents the source-free electromagnetic null-field that must describe particles (especially photons and fermions) with concrete metrics. Thus, we must be able to describe the internal structure of such particles by pure Riemannian geometry.

We use the spacetime signature (+,+,+,-).

The EFE without the cosmological constant is:

$$G_{ab} = \chi T_{ab} \qquad (2.1)$$

where we the Einstein tensor is

$$G_{ab} = R_{ab} - \frac{1}{2} g_{ab} R \qquad (2.2)$$

and the electromagnetic stress-energy tensor

$$T_{ab} = \varepsilon_0 c^2 g^{mn} F_{am} F_{bn} - \frac{\varepsilon_0 c^2}{4} g_{ab} F_{mn} F^{mn} \qquad (2.3)$$

with

$$\mu_0 \varepsilon_0 c^2 = 1$$

and

$$\chi = \frac{8\pi G}{c^4}$$

Here, G is Newton's gravitational constant, μ_0 is the permeability constant, and ε_0 is the dielectric constant in vacuum. Using the EFE and the principle that matter is "built up" of photons, we start with the source-free Maxwell equations in Riemannian space.

$$F^{mn}{}_{;n} = 0 \qquad (2.4a)$$

and

$$\tilde{F}^{mn}{}_{;n} = \frac{1}{2} \varepsilon^{mnab} F_{ab;n} = 0 \qquad (2.4b)$$

with the fully anti-symmetric 4-rank epsilon tensor in all indices, i.e.

$$\varepsilon^{mnab} = \sqrt{-g}^{\,-1} \Delta^{mnab}$$

and the Levi-Civita symbol

$$\Delta^{1234} = +1$$

changing its sign by each index exchange.

The invariants of the electromagnetic field tensor and its dual field tensor in the case of zero fields (i.e. the tensors are equal to zero) are

$$F_{mn}F^{mn} = 0 \qquad (2.5a)$$

and

$$F_{mn}\tilde{F}^{mn} = 0 \qquad (2.5b)$$

which reduce the EFE to

$$R_{ik} = k^2 F_{im}F_{kn}g^{mn} \qquad (2.6)$$

with

$$k^2 := \chi\varepsilon_0 c^2 = \frac{8\pi G\varepsilon_0}{c^2}$$

2.2 Fundamental equations of the MST:

With the MST, we aim to establish the connection to quantum mechanics by expressing the field strength tensor in bivectors μ^a and ξ^a, where μ^a may be interpreted as a kind of metric vector and ξ^a as the wave vector of the particle, as we will see later.

The bivector formulation of the electromagnetic field tensor is

$$kF^{mn} := \mu^m\xi^n - \mu^n\xi^m \qquad (2.7)$$

with the bivector conditions for the metric vector μ^a, which a a null vector, and the wave vector ξ^a, which is orthogonal to the metric vector

$$\mu^a\mu_a = 0 = \xi^a\mu_a \qquad (2.8a)$$

and

$$\xi^a\xi_a = 1 \qquad (2.8b)$$

Thus, the scalar product of the wave vector ξ^a is normalized to 1.

The Maxwell equations take the following form in Riemannian spacetime then.

$$0 = kF^{mn}{}_{;n} = (\mu^m\xi^n - \mu^n\xi^m)_{;n} = \mu^m{}_{;n}\xi^n + \mu^m\xi^n{}_{;n} - \mu^n{}_{;n}\xi^m - \mu^n\xi^m{}_{;n} \qquad (2.9a)$$

$$0 = k\tilde{F}^{mn}{}_{;n} = \frac{k}{2}\varepsilon^{mnab}F_{ab;n} = \varepsilon^{mnab}(\mu_{a;n}\xi_b + \mu_a\xi_{b;n}) = \varepsilon^{mnab}(\mu_a\xi_b)_{;n} \qquad (2.9b)$$

With the covariant derivatives

$$F^{mn}{}_{;n} = F^{mn}{}_{,n} + \Gamma^m_{nk}F^{kn} + \Gamma^n_{nk}F^{mk}$$

$$F_{ab;n} = F_{ab,n} - \Gamma^k_{an}F_{kb} - \Gamma^k_{bn}F_{ak}$$

$$\xi^m{}_{;n} = \xi^m{}_{,n} + \Gamma^m_{nk}\xi^k$$

$$\xi_{a;n} = \xi_{a,n} - \Gamma^k_{an}\xi_k$$

(2.10)

The invariants of the electromagnetic field tensor are consequently

$$0 = F_{mn}F^{mn} = \mu^a\mu_a \qquad (2.11a)$$

$$0 = F_{mn}\tilde{F}^{mn} = 2\varepsilon^{mnab}\mu_a\xi_b\mu_m\xi_n \qquad (2.11b)$$

where the first invariant corresponds to the bivector condition for the metric vector. The second invariant always leads to zero, since it is symmetric in the indices of the bivectors and antisymmetric in the indices of the epsilon tensor.

For the EFE in covariant representation, the bivector formulation implies

$$R_{mn} - \tfrac{1}{2}g_{mn}R = \chi\varepsilon_0 c^2 g^{ab}F_{am}F_{bn} - \chi\tfrac{\varepsilon_0 c^2}{4}g_{mn}F_{ab}F^{ab} \qquad (2.12)$$

with the Ricci-Tensor

$$R_{mn} = \Gamma^k_{mn,k} - \Gamma^k_{mk,n} + \Gamma^s_{sk}\Gamma^k_{mn} - \Gamma^s_{mk}\Gamma^k_{sn}$$

And the Christoffel symbols

$$\Gamma^k_{mn} = \frac{1}{2}g^{ks}(g_{ms,n} + g_{ns,m} - g_{mn,s})$$

The last term of (2.12) is zero as it is the invariant (2.11a) of the electromagnetic null-field, i.e.

$$F_{ab}F^{ab} = 0$$

When we overwrite the resulting EFE (2.1-2.3) with g^{mn}, we receive

$$g^{mn}R_{mn} - \tfrac{1}{2}g^{mn}g_{mn}R = \chi\varepsilon_0 c^2 g^{mn}g^{ab}F_{am}F_{bn} \qquad (2.13)$$

Where the right side becomes zero as it corresponds to one of the invariants of the electromagnetic null-field. Thus,

$$R - 2R = 0$$

i.e.

$$R = 0 \qquad (2.14)$$

The EFE in bivectors becomes then

$$\begin{aligned}R_{mn} &= \chi\varepsilon_0 c^2 g^{ab}F_{am}F_{bn} = g^{ab}(\mu_a\xi_m - \mu_m\xi_a)(\mu_b\xi_n - \mu_n\xi_b)\\ &= g^{ab}(\mu_a\xi_m\mu_b\xi_n - \mu_a\xi_m\mu_n\xi_b - \mu_m\xi_a\mu_b\xi_n + \mu_m\xi_a\mu_n\xi_b)\\ &= g^{ab}\mu_a\mu_b\xi_m\xi_n - g^{ab}\mu_a\xi_b\xi_m\mu_n - g^{ab}\xi_a\mu_b\mu_m\xi_n + g^{ab}\xi_a\xi_b\mu_m\mu_n\end{aligned}$$

(2.15)

Because of the bivector conditions, the first three terms are equal to zero, and only the last term remains non-zero, which means that

$$g^{ab}\xi_a\xi_b\mu_m\xi_n = \mu_m\xi_n \qquad (2.16)$$

The EFE simplify to the pure Ricci tensor being equal to the product of two metric vector components only

$$R_{mn} = \mu_m\mu_n \qquad \text{(covariant Form)} \qquad (2.17a)$$

$$R^{mn} = \mu^m\mu^n \qquad \text{(contravariant Form)} \qquad (2.17b)$$

This simple form of (2.12) leads to the following relationship between the diagonal and non-diagonal elements of the Ricci-Tensor.

$$R^{mm} = (\mu^m)^2 \qquad (2.18a)$$

and

$$(R^{mn})^2 = R^{mm}R^{nn} \qquad (2.18b)$$

The divergence free Ricci tensor in the EFE leads to

$$0 = R^{mn}{}_{;n} = \chi T^{mn}{}_{;n} = \mu^m \mu^n{}_{;n} + \mu^m{}_{;n}\mu^n$$

i.e.

$$\mu^m{}_{;n}\mu^n = -\mu^m \mu^n{}_{;n} \qquad (2.19)$$

The MST in the bivector formalism is consequently to be summarized by the following three equations, where the first is the EFE and the last two are the source-free Maxwell equations:

$$\boldsymbol{R^{mn} = \mu^m \mu^n}$$

$$\boldsymbol{(\mu^m \xi^n - \xi^m \mu^n)_{;n} = 0}$$

$$\boldsymbol{\varepsilon^{mnab}(\mu_a \xi_b)_{;n} = 0}$$

(2.20)

These are the fundamental equations of MST and are especially remarkable due to the fact that they do not contain any natural constants, i.e. they are independent of any system of units.

The two Maxwell equations (2.4), $0 = F^{mn}{}_{;n}$ and $0 = \tilde{F}^{mn}{}_{;n}$ may be summarized in one complex equation

$$F^{mn}{}_{;n} + i\tilde{F}^{mn}{}_{;n} = 0 \qquad (2.21a)$$

which result in the bivector formalism in the form

$$\boldsymbol{(\mu^m \xi^n - \xi^m \mu^n)_{;n} + i\varepsilon^{mnab}(\mu_a \xi_b)_{;n} = 0} \qquad (2.21b)$$

The bivector $\boldsymbol{\mu^m}$ has as null-vector ($\mu^a \mu_a = 0$) the character of a **metric vector**, as it describes the Ricci tensor purely (see (2.17b): $R^{mn} = \mu^m \mu^n$) and the Ricci-Tensor is constructed by the metric tensor and its derivatives only.

The bivector $\boldsymbol{\xi^s}$ has the character of a **wave vector**, as it is a no null-vector with the scalar value normed to 1 (see (2.8b): $\xi^a \xi_a = 1$).

In accordance with the fundamental principles of MST, the MST equations in bivectors must be the generalization of quantum mechanics (especially electrodynamics) in Riemannian space, where the metric vector μ^m describes the Riemannian spacetime structure and the wave vector ξ^s the wavefunction of a particle.

However, due to the curved structure of Riemannian spacetime, the partial derivatives in MST are replaced by covariant derivatives.

We can express the complex Maxwell equations in bivector formulation as a function of the wave vector ξ^s and its first derivatives $\xi^s{}_{;n}$, as we will show in the following section.

3. Conclusions of the MST

3.1 Maxwell equations in bivectors:

We start here with the Maxwell equations in complex form and bivector formalism (2.21b)

$$0 = (\mu^m \xi^n - \xi^m \mu^n)_{;n} + i\varepsilon^{mnab}(\mu_a \xi_b)_{;n}$$

Distributing the covariant derivative on all vectors

$$0 = \mu^m{}_{;n}\xi^n + \mu^m \xi^n{}_{;n} - \mu^n{}_{;n}\xi^m - \mu^n \xi^m{}_{;n} + i\varepsilon^{mnab}(\mu_{a;n}\xi_b + \mu_a \xi_{b;n})$$

where the vectors are used in their contravariant form

$$0 = \mu^m{}_{;n}\xi^n + \mu^m \xi^n{}_{;n} - \mu^n{}_{;n}\xi^m - \mu^n \xi^m{}_{;n} + i\varepsilon^{mnab} g_{ak} g_{bs}(\mu^k{}_{;n}\xi^s + \mu^k \xi^s{}_{;n})$$

and linked to the wave vector and its covariant derivative

$$0 = \left(\mu^m{}_{;n}\delta^n{}_s - \mu^n{}_{;n}\delta^m{}_s + i\varepsilon^{mnab} g_{ak} g_{bs}\mu^k{}_{;n}\right)\xi^s + (\mu^m \delta^n{}_s - \mu^n \delta^m{}_s + i\varepsilon^{mnab} g_{ak} g_{bs}\mu^k)\xi^s{}_{;n} \tag{3.1a}$$

we obtain

$$0 = (\delta^m{}_k \delta^n{}_s - \delta^n{}_k \delta^m{}_s + i\varepsilon^{mnab} g_{ak} g_{bs})\mu^k{}_{;n}\xi^s + (\delta^m{}_k \delta^n{}_s - \delta^n{}_k \delta^m{}_s + i\varepsilon^{mnab} g_{ak} g_{bs})\mu^k \xi^s{}_{;n} \tag{3.1b}$$

When we define

$$\phi^{mn}_{ks} := +\delta^m{}_k \delta^n{}_s - \delta^n{}_k \delta^m{}_s + i\varepsilon^{mnab} g_{ak} g_{bs} \tag{3.2a}$$

$$f^{mn}_{\ \ s} := [+\delta^m{}_k \delta^n{}_s - \delta^n{}_k \delta^m{}_s + i\varepsilon^{mnab} g_{ak} g_{bs}]\mu^k = \phi^{mn}_{ks}\mu^k \tag{3.2b}$$

with the covariant constant term ϕ^{mn}_{ks} (i.e. $\phi^{mn}_{ks;w} = 0$), which leads to

$$0 = \phi^{mn}_{ks}\mu^k{}_{;n}\xi^s + \phi^{mn}_{ks}\mu^k \xi^s{}_{;n} = (\phi^{mn}_{ks}\mu^k \xi^s)_{;n} = \phi^{mn}_{ks}(\mu^k \xi^s)_{;n} \tag{3.3a}$$

resp.

$$0 = f^{mn}{}_{s;k}\xi^s + f^{mn}{}_s \xi^s{}_{;n} = (f^{mn}{}_s \xi^s)_{;n} \tag{3.3b}$$

Thus, the Maxwell equations in Riemannian spacetime can be expressed in bivectors in a covariant linear form with respect to the wave vector ξ^s.

We can extend the above equations (3.3) by a gauge tensor E^{mn}, as we can multiply the bivector condition (2.8a) with zero value

$$0 = \mu_s \xi^s = g_{ks}\mu^k \xi^s$$

by an arbitrary gauge tensor E^{mn} as follows

$$0 = (E^{mn} g_{ks}\mu^k \xi^s)_{;n} = E^{mn} g_{ks}\mu^k{}_{;n}\xi^s + E^{mn} g_{ks}\mu^k \xi^s{}_{;n} \tag{3.4}$$

and add it to the Maxwell equation (3.18).

$$0 = (\phi_{ks}^{mn} - E^{mn} g_{ks}) \mu^k{}_{;n} \xi^s + (\phi_{ks}^{mn} - E^{mn} g_{ks}) \mu^k \xi^s{}_{;n} \qquad (3.5)$$

We have chosen the above form of the gauge term in correlation with the Maxwell equation indexation.

In a further paper we show that the above Maxwell equations with the gauge term contain the Dirac equation as a special case.

3.2 The concept of mass in MST:

The MST is based on null-fields in Riemannian spacetime, resulting in equations which, unlike in quantum mechanics, do not explicitly include scalar mass values.

The concept of mass in MST is far more profound than in any classical theory such as classical relativity or quantum mechanics. It is not simply a given point or extended region to which a scalar mass quantity is linked.

In the MST, mass arises from the fundamental principle of matter-spacetime equivalence within the EFE, explicitly from the energy-momentum tensor of a cosmologically extended energy density distribution. As the T_{44} component of the stress-energy tensor is the energy density of a matter distribution with the volume element

$$dV = \sqrt{-g}\, dx^1\, dx^2\, dx^3\, dx^4 \qquad (3.6)$$

the mass calculation of any particle or matter distribution comes out of the following integral over the whole cosmological space volume

$$m = \frac{E}{c^2} = \frac{1}{c^2} \iiint T_{44}\, dV = \frac{1}{c^2} \iiint \sqrt{-g}\, T_{44}\, dx^1\, dx^2\, dx^3 \qquad (3.7a)$$

Due to (2.2) and (2.3)

$$R_{ab} = g_{am} g_{an} \mu^m \mu^n = \chi T_{ab}$$

we have

$$T_{ab} = \frac{1}{\chi} g_{am} g_{an} \mu^m \mu^n$$

and thus, the mass integral is

$$m = \frac{1}{\chi c^2} \iiint \sqrt{-g}\, g_{4m}\, g_{4n}\, \mu^m\, \mu^n\, dx^1\, dx^2\, dx^3 = \frac{1}{\chi c^2} \iiint \sqrt{-g}\, (\mu_4)^2\, dx^1\, dx^2\, dx^3$$

(3.7b)

The mass resp. energy of a particle or extended object depends solely on the metric tensor and the metric vector μ^m, which has the dimension 1/length, and is therefore a pure function of spacetime. We thus conclude:

Mass resp. Energy = Scalar of spacetime structure

From the above consideration of the energy/mass concept within the framework of the MST fundamental principles, it further becomes clear that a strict distinction between mass and energy is not necessary, since every mass possesses relative to its energy a self-bound (with rest mass) or free energy structure and differs from its mass by the factor $1/c^2$.

The difference between mass and energy is therefore that mass is a self-bound state of energy in the Riemannian spacetime structure. Energy, on the other hand, is a free state of matter, which propagates at the speed of light along zero geodesics in the Riemannian spacetime structure.

According to the logic of the mass integral in MST, particles can thus be stable if they do not have just a structure (metric), but if the mass integral converges over their metric as well, meaning that the mass integral results in a finite value on the full cosmic range.

3.3 Inhomogeneous Maxwell equations and electric charge:

Since we base MST on null-fields, i.e. on source-free Maxwell's equations in a vacuum, we will now discuss the inhomogeneous Maxwell's equations within the framework of MST.

Just as we formulated the second principle of MST, which states that all matter must be composed of null-fields in Riemannian spacetime (RS), we show that the inhomogeneous Maxwell's equations in flat Minkowski spacetime (MS) result from the source-free Maxwell's equations (null-fields) of RS.

The inhomogeneous and homogeneous Maxwell's equations in a vacuum in MS are as follows:

$$F^{mn}{}_{,n} = \mu_0 J^m \qquad (3.8a)$$

$$\tilde{F}^{mn}{}_{,n} = 0 \qquad (3.8b)$$

with the four-current density J^m.

In comparison, let us consider the source-free Maxwell equations in the curved RS (2.4), where we have covariant derivatives instead of the partial derivatives of the flat MS.

$$F^{mn}{}_{;n} = 0$$

$$\tilde{F}^{mn}{}_{;n} = 0$$

When writing out the covariant derivatives (2.10) in partial ones with the covariant correction terms, we obtain

$$0 = F^{mn}{}_{,n} + \Gamma^m_{nk} F^{kn} + \Gamma^n_{nk} F^{mk} = F^{mn}{}_{,n} + \left[ln\sqrt{-g}\right]_{,n} F^{mn}$$

(3.9a)

$$0 = \tilde{F}^{mn}{}_{;n} = 0{,}5\ \varepsilon^{mnab} F_{ab;n} = 0{,}5\ \varepsilon^{mnab}\left(F_{ab,n} - \Gamma^k_{an} F_{kb} - \Gamma^k_{bn} F_{ak}\right) = 0{,}5\ \varepsilon^{mnab} F_{ab,n}$$

(3.9b)

where the gray marked terms become zero, specifically, in the first equation (3.9a) due to the anti-symmetry of F with respect to the symmetric Christoffel symbols, and in the second equation (3.9b) due to the anti-symmetry of the epsilon tensor with respect to the symmetric Christoffel symbols.

If the solutions in RS satisfy the above equations (3.9), for example, for electrons, which must have a very sharp energy density distribution in the subatomic region with most probable detection, then the solutions in MS appear "from a distance" as if the strong spacetime deformation within the extreme energy density distribution would not be a deformation, but a massive source.

Therefore, the Christoffel term of the first equation (3.9a) in RS must correspond to the four-current density in MS, i.e.

$$\mu_0 J^m = -\left[ln\sqrt{-g}\right]_{,n} F^{mn} = \left[ln\sqrt{-g}\right]_{,n} F^{nm} \qquad (3.10)$$

with

$$J^m = \rho v^m$$

where ρ is the charge density of the particle or any extended object and v^m the four-velocity with

$$\rho = \rho(x^1, x^2, x^3, ct)$$

$$v^m = (v^1, v^2, v^3, c)$$

$$v^m = v^m(x^1, x^2, x^3, ct)$$

$$(3.11)$$

The fact that the second equation (3.9b) does not have any inhomogeneous terms, corresponds exactly to the homogeneous Maxwell equation without any massive resp. charged terms.

We write out (3.10) in its components

$$\mu_0 J^1 = \mu_0 \rho v^2 = +\left[ln\sqrt{-g}\right]_{,1} F^{11} + \left[ln\sqrt{-g}\right]_{,2} F^{21} + \left[ln\sqrt{-g}\right]_{,3} F^{31} + \left[ln\sqrt{-g}\right]_{,4} F^{41}$$

$$\mu_0 J^2 = \mu_0 \rho v^2 = +\left[ln\sqrt{-g}\right]_{,1} F^{12} + \left[ln\sqrt{-g}\right]_{,2} F^{22} + \left[ln\sqrt{-g}\right]_{,3} F^{32} + \left[ln\sqrt{-g}\right]_{,4} F^{42}$$

$$\mu_0 J^3 = \mu_0 \rho v^3 = +\left[ln\sqrt{-g}\right]_{,1} F^{13} + \left[ln\sqrt{-g}\right]_{,2} F^{23} + \left[ln\sqrt{-g}\right]_{,3} F^{33} + \left[ln\sqrt{-g}\right]_{,4} F^{43}$$

$$\mu_0 J^4 = \mu_0 \rho c \quad = +\left[ln\sqrt{-g}\right]_{,1} F^{14} + \left[ln\sqrt{-g}\right]_{,2} F^{24} + \left[ln\sqrt{-g}\right]_{,3} F^{34} + \left[ln\sqrt{-g}\right]_{,4} F^{44}$$

When setting all velocity components to zero ($v^m = 0$) apart from m=4 (here is $v^4 = c$), the m=4 equation in (3.10) leads to an inconsistency, as may be shown easily. The charge density, at least on a subatomic range, can never be static therefore. Nevertheless, an extended charge distribution may reveal as static on a macroscopic scale in total superposition of all single particles.

With the above resulting charge density

$$\rho = \varepsilon_0 c \left[ln\sqrt{-g}\right]_{,n} F^{n4} \qquad (3.12)$$

we obtain the charge Q of a particle or a charged, extended matter distribution from the following integral (compare it with the mass integral (3.7))

$$Q = \iiint \sqrt{-g}\ \rho\, dx^1\, dx^2\, dx^3 = \varepsilon_0 c \iiint \sqrt{-g}\ \left[ln\sqrt{-g}\right]_{,n} F^{n4}\, dx^1\, dx^2\, dx^3$$

(3.13a)

and further simplified

$$Q = \varepsilon_0 c \iiint \left(\sqrt{-g}\right)_{,n}\ F^{n4}\, dx^1\, dx^2\, dx^3 = \varepsilon_0 \iiint \left(\sqrt{-g}\right)_{,n}\ E^{n}\, dx^1\, dx^2\, dx^3$$

(3.13b)

where E^n is the electric field vector of a particle or a charged, extended matter distribution concerned.

4. Summary and outlook

The fundamental equations of MST, which do not contain any natural constants, primarily represent a general formulation of the unification of gravitation and electromagnetism. This unification applies both in the subatomic range (quantum range) and in the macroscopic range (classical and cosmological range).

MST eliminates the problem of wave-particle duality, since every particle is a wave extended across the entire universe (i.e. we have cosmological functions in RS) with an extremely sharp energy density distribution in the subatomic range at the location with the highest probability. Therefore, in the sense of MST, there are only particle waves and no "point-like" particles. Nevertheless, the probability of measurements or indeterminism in the sense of quantum mechanics is not questioned by that, as we always measure waves with waves, which do not change the fact of uncertainty of any measurement.

In the further following paper, we will discuss the Dirac equation in RS, which represents a special solution of MST in the quantum range.

We will further present simple solutions for the macroscopic range of MST, which describe the generation of gravitational fields due to electromagnetic sources. Thus, MST provides approaches to solutions for gravitational compensators, electro-gravitational propulsions, etc.

Furthermore, the question arises whether the MST could explain all four fundamental forces of nature. It is conceivable that the combination of electromagnetic fields within extremely deformed Riemannian spacetime (RS) in the subatomic range could lead to all four fundamental forces. For example, strong interaction could result from an extreme spacetime curvature in a subatomic range, in which high-energy photons are trapped, i.e. self-bound, and interact electro-gravitationally with each other within such a range.

In particular, concrete metrics of elementary particles should be derivable from the fundamental equations of MST. That is why we have chosen the term Matter Structure Theory, since the fundamental equations of MST must describe the metric and field structure of particles and extended matter structures.

In the cosmological range, for example, the rotational speeds of galaxies could be investigated, since, unlike classical physics, MST postulates energy density distributions for matter that is extended across the entire cosmos and continuously differentiable. Classical physics, including classical general relativity, always assumes spatially limited matter distributions, i.e., mass or energy density distributions with central sources, which consequently lead to the geometric $1/r^2$ dependence of all fields. MST, on the other hand, could generate stronger action at a distance due to the cosmologically extended energy density distributions of matter, which could explain higher rotational speeds in the outer regions of galaxies without the postulated and as-yet-undiscovered dark matter and energy.

Since the solutions to the EFE and the source-free Maxwell equations must be simultaneously satisfied in the bi-vector formalism, all solutions must be derived from very elaborate and difficult mathematical derivations.