4. Conclusions

Summarizing, in curved spacetime ($g_{\alpha\beta} = h_{\alpha\beta}$) the main equation of the proposed solution (48) expresses the Einstein Field Equations with an accuracy of $\frac{4\pi G}{c^4}$ constant and with cosmological constant Λ dependent on invariant of electromagnetic field tensor $\mathbb{F}^{\alpha\gamma}$

$$\Lambda = -\frac{\pi G}{c^4 \mu_o}\mathbb{F}^{\alpha\mu} h_{\mu\gamma} \mathbb{F}^{\beta\gamma} h_{\alpha\beta} = -\frac{4\pi G}{c^4}\Lambda_\rho, \tag{52}$$

where $h_{\alpha\beta}$ is the metric tensor of the spacetime in which all motion occurs along geodesics and where Λ_ρ describes vacuum energy density. These EFE drive to classic Schwarzschild and Kerr vacuum solutions, as shown in (51).

Stress–energy tensor $T^{\alpha\beta}$ for the system in a given spacetime described by some metric tensor $g^{\alpha\beta}$ is equal to

$$T^{\alpha\beta} = \varrho U^\alpha U^\beta - (c^2\varrho + \Lambda_\rho)(g^{\alpha\beta} - \xi h^{\alpha\beta}), \tag{53}$$

where $c^2\varrho$ is energy density and where

$$\frac{1}{\xi} = \frac{1}{4} g_{\mu\nu} h^{\mu\nu}, \tag{54}$$

$$\Lambda_\rho \equiv \frac{1}{4\mu_o}\mathbb{F}^{\alpha\mu} g_{\mu\gamma} \mathbb{F}^{\beta\gamma} g_{\alpha\beta}, \tag{55}$$

$$h^{\alpha\beta} = 2\frac{\mathbb{F}^{\alpha\delta} g_{\delta\gamma} \mathbb{F}^{\beta\gamma}}{\sqrt{\mathbb{F}^{\alpha\delta} g_{\delta\gamma} \mathbb{F}^{\beta\gamma} g_{\mu\beta} \mathbb{F}_{\alpha\eta} g^{\eta\xi} \mathbb{F}^{\mu}{}_{\xi}}}. \tag{56}$$

In flat Minkowski spacetime ($g^{\alpha\beta} \equiv \eta^{\alpha\beta}$) according to (37) vanishing four-divergence of the proposed stress–energy tensor ($\partial_\beta T^{\alpha\beta} = 0$) turns out to be relativistic Cauchy momentum equation which is the expected relationship.

To reproduce movement in curved spacetime, it will be more convenient to define flat Minkowski spacetime using the metric tensor given in polar coordinates

$$g_{\alpha\beta} \equiv \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -r^2 & 0 \\ 0 & 0 & 0 & -r^2\sin^2(\theta) \end{bmatrix}. \tag{57}$$

Total force density f^α acting in the system calculated from $\partial_\beta T^{\alpha\beta} = 0$ is equal to

$$f^\alpha = \begin{cases} f^\alpha_{\mathrm{EM}} \equiv -\Lambda_\rho \partial_\beta \xi h^{\alpha\beta} \quad \text{(electromagnetic)}, \\ + \\ f^\alpha_{\mathrm{gr}} \equiv c^2(g^{\alpha\beta} - \xi h^{\alpha\beta})\partial_\beta \varrho \quad \text{(gravitational)}, \\ + \\ f^\alpha_{\mathrm{oth}} \equiv -\varrho c^2 \partial_\beta \xi h^{\alpha\beta} \quad \text{(other)}. \end{cases} \tag{58}$$

One may also transform force densities from continuum description (density in the considered volume) to discrete description (point-like masses, charges, etc.)

$$F^{\alpha} \equiv \frac{1}{\gamma} \int_V f^{\alpha} dV, \tag{59}$$

where V denotes volume and where $1/\gamma$ in above expressions is the result of the amendment to the continuum mechanics introduced in Eqs. (12) and (20) what was shown as actually expected to keep the continuum mechanics consistent with the Lorentz transformation.

Considering ϱ as volumetric mass density one obtains mass-dependent forces where thanks to (11) it may be substituted

$$\partial_{\beta} \varrho = \varrho \partial_{\beta} \ln(\gamma). \tag{60}$$

Since

$$-\Lambda_{\rho} = \frac{1}{2\mu_o} \left(\frac{E^2}{c^2} - B^2 \right) \tag{61}$$

the result of the integral of the above is unknown. One may therefore introduce a parameter E_{Λ} with the dimension of energy

$$\frac{1}{\gamma} E_{\Lambda} \equiv \frac{1}{\gamma} \int_V -\Lambda_{\rho} dV. \tag{62}$$

Total force acting on the test body in the system may be now expressed as

$$F^{\alpha} = \begin{cases} F^{\alpha}_{\mathrm{EM}} \equiv \frac{1}{\gamma} E_{\Lambda} \partial_{\beta} \xi h^{\alpha\beta} \quad \text{(electromagnetic)}, \\ + \\ F^{\alpha}_{\mathrm{gr}} \equiv \mathrm{m}c^2 (g^{\alpha\beta} - \xi h^{\alpha\beta}) \partial_{\beta} \ln(\gamma) \quad \text{(gravitational)}, \\ + \\ F^{\alpha}_{\mathrm{oth}} \equiv -\mathrm{m}c^2 \partial_{\beta} \xi h^{\alpha\beta} \quad \text{(other)}, \end{cases} \tag{63}$$

and, according to previous section, it reproduces motion in curved spacetime given by metric tensor $h^{\alpha\beta}$ with presence of vacuum energy (nonzero cosmological constant).

The above equations may be tested with various spacetimes described by different metric tensors $h^{\alpha\beta}$ and can also be further developed by extending the proposed stress–energy tensor and additional parametrization.

5. Discussion

The presented solution creates a coherent picture in which spacetime is in fact a way of perceiving the electromagnetic field (what also explains Eq. (6)). This solution allows for further development, introducing additional fields, different parameterization and simple transformation between Minkowski spacetime and curvilinear reference systems. It should be noted that the proposed solution does not question the correctness of the currently existing, well-established physical theories, but rather leads to their integration, opening up a new field for further research, experimental verification and tuning.

The resulting description of the gravitational interaction is a solution of the Einstein Field Equations, reproduces GR with cosmological constant Λ, complies with equations of continuum mechanics and adds components that may help explain phenomena that cannot be described with GR today. This description of gravity is also open for parameterization, development and further study of this approach in search of explanation of cosmological issues. Perhaps description of forces present in the paper and the possibility of the dual description of the movement (curved spacetime versus flat spacetime with fields and forces) may help to explain the phenomenon described today as Dark Energy[42,43] or explain why some fast-orbiting bodies in selected galaxies may feel less repulsive force[44,45] reducing, at least in part, the need to use Dark Matter[46–48] in the system description. It may also help with unexplained phenomena related to very massive objects that elude the currently used description of gravity[49–52] or help with explanation of Hubble tension problem.[53–55]

The author intentionally does not perform the parameterization on his own because his intention is not to create a theory explaining all the contemporary challenges of physics, but only to add his own brick to the whole knowledge by creating coherent framework that will allow the broad scientific community for further theoretical and experimental research.

It is also necessary to discuss the force density $f^{\alpha}_{\mathrm{oth}}$ that occurs naturally in Eq. (33). This force density, interpreted here as "other interactions", seems to be related to strong interactions, or sum of strong and weak interactions, what would link both phenomena with additional electromagnetic force density moderated by the density of energy. This is supported by the observation that on small scales with high energy density, the density of this force will be extremely great — one may recognize it as a strong interaction property. On larger scales with small energy density, this force will be extremely weak — one may recognize it as a weak interaction property. It is also known that both of these interactions on quantum level are to some extent related to electromagnetism (charged quarks or bosons). Also the relation between strong forces and gravity has already been noted by the double copy theory.[56–58]

Due to the lack of equations describing the weak and strong fields in classical field theory, confirmation of the proposed relationship of these fields with force density $f^{\alpha}_{\mathrm{oth}}$ must take place on the basis of quantum theories, where Eq. (33) is a quantitative prediction that can be verified or expanded with additional components in the proposed stress–energy tensor. It also creates a new area of research to confirm the above approach or for further analysis of weak and strong interactions based on classical field theory by developing the proposed solution.

It is also debatable whether it is possible to describe the motion of a cloud of differently charged test particles using a uniform metric. Although the mathematically obtained description seems correct, the very idea of describing a combination of electromagnetic and gravitational fields as an effect of geodesics in a common spacetime seems counterintuitive. This certainly requires further discussion and theoretical research.

Finally, it is worth noting that cosmological constant Λ in above solution is certainly not "Einstein's greatest mistake", but appears to be a measure for the value of invariant of the electromagnetic field tensor. Since electromagnetic field fills each considered volume regardless of its selection (from the scale of the atom to the entire space), it turns out to be a surprisingly natural explanation to the vacuum energy problem. It also may be further parameterized and extended with invariants of other fields introduced to the above solution.

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