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Research Article

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Posted Date: November 30th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-1099268/v4>

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GEOMETRIC MEDIATOR STRUCTURES, TRANSITION DYNAMICS AND FORCE CONSTANTS

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Summary

A comprehensive description or model of the universe at the fundamental level which improves on the Newtonian r^{-4} (infinity at $r = 0$ labelled a singularity) gravitational force model is proposed. Matter and force concepts are to be replaced by more *ab initio* or *first principle* energy and geometric-modeling. We have produced a description of matter as a geometric-mimic, a “distorted geometry” structure, formulated from a solution of Riemann’s geometric equations (see Supplementary Information below). The model is essentially the “Curved empty space as the building material of the physical world” supposition of Clifford [1] in 1876 and is the conceptual basis for this “distorted-geometry” modeling. The resulting geometric description of matter (mass-energy) mimics the classical-physics electromagnetic and gravitational-field models at large radii but departs significantly at small radii to produce a magnetic-field (spin) mimic as well as a weak-field mimic (beta decay and the Fermi constant) and a strong-field mimic without an infinity at the origin (no singularity). The structure is constituted by a core-

region within which the propagation-velocity, by virtue of the distorted metrics, is greater than c and exhibits a “partial light trapping phenomenon”, facilitating and duplicating “black hole” behavior. Distorting the geometry in our spatial-manifold requires energy but with limits as to the degree of distortion thereby predicting and describing fundamental-electromagnetic-particle structures as well as gravitational (dark-matter, black-hole) structures. Such a geometric description of localized warping or distorting of the spacetime manifold would seem (?) to constitute a “first-principle” model of the universe. The work also describes geometric “energy-transition mediator” structures.

A historical quote from Wheeler’s work [2-3] published in 1955 reads; “In the 1950’s, one of us [4] found an interesting way to treat the concept of body in general relativity. An object can in principle be constructed out of gravitational radiation or electromagnetic radiation, or a mixture of the two, and may hold itself together by its own gravitational attraction...A collection of radiation held together in this way is called a geon (a gravitational electromagnetic entity) and is a purely classical object....In brief, a geon is a collection of gravitational or electromagnetic energy, or a mixture of the two, held together by its own gravitational attraction, that describes *mass without mass*.”

Subsequently at *The International Congress for Logic, Methodology, and Philosophy of Science* in 1960, he [4] began by quoting William Kingdon Clifford’s [1] “Space-Theory of Matter” of 1870 and stated “The vision of Clifford and Einstein can be summarized in a single phrase, ‘a geometrodynamical universe’: a world whose properties are described by geometry, and a geometry whose curvature changes with time – a dynamical geometry.”

Additional work in this field continues, some of which is cited in references [5-10]. The present treatment departs from these cited “geon constructional methods” in that we do not

constrain the distortional descriptions to only gravitational coupling-constant produced structures.

The present resulting geometric description of matter (mass-energy) mimics the classical-physics electromagnetic and gravitational-field models at large radii but departs significantly at small radii to produce a magnetic-field (spin) mimic as well as a weak-field mimic (beta decay and the Fermi constant) and a strong-field mimic without an infinity at the origin (no singularity) [11]. The structure is constituted by a core-region within which the propagation-velocity, by virtue of the distorted metrics, is greater than c and exhibits a “partial light trapping phenomenon”, a “black hole”. Warping or distorting our spatial-manifold requires energy but with limits as to the degree of distortion thereby predicting and describing fundamental-electromagnetic-particle structures as well as gravitational (dark-matter, black-hole) structures.

Abstract

It is shown in the present work that the distorted-space model of matter can describe conventional force-constants and transition-mediator structures. We use the verbiage “distorted” to communicate the concept of “energetic warping” to distinguish “spatial warping” from “classical matter warping”, although the concept of “matter” is in fact, in the present context, the “geometric distortion energy” of the spatial manifold itself without a classical “matter stress-energy source”. The “distorted-geometry” structures exhibit non-Newtonian features wherein the hole or core-region fields of the structures are energetically-repulsive (negative pressure), do not behave functionally in an r^{-4} manner and terminate at zero at the radial origin (no singularity). Near the core of the distortion the magnetic fields dominate the energy-densities of the structures thereby departing from classical particle-structure descriptions. Black-body radiation-emission and structural modeling lead to a description of transition dynamics and photonic entities.

Introduction

Physical transition processes are presently mathematically represented in “quantum-terms” as a manifestation of a “strength-of-interaction coupling-constant” operating on an “initial-state” wave-function particle-descriptor to produce a “final-state” different wave-function particle-descriptor; one particle transforms to another particle (a different energy-state) via the forces present at the transformation site. The actual physical description of the structural-changing dynamics is not part of this quantum-mechanical operational-mathematical rendering although an “intermediate” mediator-structure [12] is envisioned.

The intermediate mediator-structure in the beta-decay transition process, the conversion of a neutron into a proton, electron and a neutrino, is a WBOSON PARTICLE and the “strength-of-

interaction” has been labelled “the Fermi-constant GF” after the physicist who successfully modelled this physical process.

We have also successfully and precisely modelled and mimicked this transition process in the “distorted-geometry” model of matter [11] as a product of boson mass-energy and boson physical-volume, a “geometric maximum-curvature condition” and a magnetic-field based (r^{-6}) distortion-energy, with structural details which are not forthcoming in present-day quantum mechanics, force-carrier-fields [12] notwithstanding.

Theoretical Foundations

Fundamental theoretical and mathematical foundations for this undertaking are presented in the Supplementary Information section.

Calculational Methods for Mediator Modeling

For the “distorted-geometry, maximum-curvature” model, precise to the mass-characterization of the W-boson,

$$\begin{aligned} \mathbf{Fd}_{\text{mag}}^2 r^6 \pi^4 &= \frac{1}{8\pi\kappa} 2 R_s R_0^3 \pi^4 = \frac{\pi^3}{2} m_w c^2 R_0^3 = \\ &\equiv \text{GF}(\text{distorted geometry}) = \\ &= \text{GF}(\text{Fermi}) = 1.435851 \cdot 10^{-62} \text{ Joule meters}^3 . \end{aligned} \quad (1)$$

The energy-density for the $\mathbf{Fd}_{\text{mag}}^2$ component evaluated @ $r = R_0$ is

$$\frac{1}{2\pi} m_w c^2 R_0^3 R_0^{-6} = 2.87 \cdot 10^{46} \frac{\text{Joule}}{\text{meter}^3} . \quad (2)$$

The “distorted-geometry” mathematical symbols are

$$\begin{aligned}\kappa &\equiv \kappa_{EM}(mc^2, Q) = W_{boson} \text{coupling constant} = \alpha \frac{\hbar c}{2} \left(\frac{Q}{3 m_w c^2} \right)^2 \\ &= 6.93 \cdot 10^{-13} \frac{\text{meters}}{\text{Joule}},\end{aligned}$$

$\alpha = \text{fine structure constant}$.

$\hbar = \text{Planck's constant}$, $c = \text{velocity of light}$ and $m_w = \text{boson mass}$.

The distorted-geometry radial descriptor R0 is

$$R0 = \left(\alpha \frac{2}{3} \left(S \frac{geQ}{2 \cdot 3} \right)^2 \right)^{1/3} \hbar c (mc^2)^{-1} , \quad (2a)$$

where S = spin quantity (S = 1 for the boson), ge = gyromagnetic ratio and Q = electric charge quantity (Q = 3 for the boson), then,

$$R0_w = \left(\alpha \frac{2}{3} \right)^{1/3} \hbar c (m_w c^2)^{-1} \text{ and } Rs_w = 2 \kappa m_w c^2 .$$

The energy-density structural nature of the ‘distorted geometry’ solution [11] (Eq. (SI-4)),

$$\mu' = \frac{2(1 - u^3)u^2}{(Iu - \gamma)R0} , \quad u \equiv \frac{R0}{r} ,$$

gives rise inherently and comprehensively to the fundamental force quantities ($\mathbf{Fd}_{12}$, $\mathbf{Fd}_{13}$, and $\mathbf{Fd}_{14}$), heretofore characterized as independent entities; a *weak-magnetic-force*, an *electric-force* and a *strong-force* at the *nuclear core*. These force characterizations are here manifested as r^{-6} , r^{-4} and complex repulsive-core r^{-n} components of the “one geometric structure”. The structure is a balanced internal/external high-energy-density configuration, the difference in internal-pressure vs external-pressure manifested as particle mass-energy. The magnitude of the structural energy-density descriptor function is determined by the mass-energy or geometric-curvature with a geometry-to-energy coupling constant (meters/Joule) also dependent on these physical characteristics; a constant coupling-constant component describes

gravitational structures. The “distorted-geometry-solution ($\equiv DG$)”, is generated from Riemann’s geometric description of a 4-dimensional spacetime manifold applied at localized warped- or distorted-space energy centers.

With the geometric success of mimicking the Fermi-constant as a particle-structure descriptor (the W-boson), which is a “*mass-energy** $R0^3$ “product and which is a *magnetic energy-density weak-force maximum* and a *geometric-curvature maximum (inverse dependence)* [11], we posit gravitational, electromagnetic and strong (core)-force “*strength-of-interaction-DG*” constants as energy-density coefficients of the various r -dependent components of a DG W-boson structure.

However since such tensor-force $((\mathbf{Fd}_{14})^2, (\mathbf{Fd}_{\text{mag}})^2 \text{ and } (\mathbf{Fd}_{\text{core}})^2)$ entities are geometrically coupled entities, the classical “independently separable” model (*weak* plus *EM* plus *strong*) is not applicable. We instead use the energy-density maxima in the core region and in the extra-core region to establish the physical strengths of the classical-differentiated force functions. We use the “BLACK-HOLE DISTORTIONAL EXTREMUM [13] (a minimum hole mass) mass-energy” for calculating the “*gravitational-interaction-strength*” constant GG. Note that the “gravitational coupling-constant, $G*c^{-4} = 0.826 \cdot 10^{-44}$ meters/Joule, is ~32-42 orders of magnitude smaller than the “EM (electromagnetic) coupling-constants” κ_W or κ_{electron} .

Calculational Method for the W-boson

The positive-pressure (positive energy-density) quantity, $(\mathbf{Fd}_{14})^2(Q \neq 0)$, evaluated at the core-radius functional-extremum, for the W-boson, is

$$\begin{aligned} \mathbf{Fd}_{14}^2(r^{-4} \text{ component}) &= \frac{Rs^2}{2} \frac{1}{8\pi\kappa} \frac{1}{r^4} = \frac{\hbar c}{8\pi} \alpha \frac{1}{R0_W^4} = \\ &= \left(\frac{3}{2}\right)^{\frac{4}{3}} \left(\frac{1}{\alpha}\right)^{\frac{1}{3}} \frac{(m_W c^2)^4}{8\pi(\hbar c)^3} \text{ (Joule/meter}^3\text{)}. \end{aligned} \quad (3)$$

The actual DG functional value at the energy-density maximum is $7.64 \cdot 10^{47} \frac{\text{Joules}}{\text{meter}^3}$ @ $r = 2.37 \cdot 10^{-19} \text{ meters}$ while the classical r^{-4} value is

$$\mathbf{Fd}_{14}^2(r^{-4} \text{ component}) = \frac{R_s^2}{2} \frac{1}{8\pi\kappa} \frac{1}{r^4} = 2.89 \cdot 10^{45} \text{ Joules/meter}^3 \text{ @ } r = 2.37 \cdot 10^{-19} \text{ meters},$$

illustrating the magnitude of the contribution to $\mathbf{Fd}_{14}^2$ from the r^{-6} and other r^{-n} components.

Similarly, the negative-pressure (negative energy-density) core-maximum (for a W-boson structure) is

$$(\mathbf{Fd}_{boson \ core})^2(\text{max @ } r = 1.46 \cdot 10^{-19} \text{ meter}) = -2.51 \cdot 10^{48} \text{ Joule/meter}^3 \equiv \quad (4)$$

$$\equiv \text{strong force energy density maximum} = 869 \mathbf{Fd}_{14}^2(r^{-4} \text{ component}) =$$

$$= 87.5 \mathbf{Fd}_{mag}^2(r^{-6} \text{ component}).$$

These field quantities are displayed in Fig.1.

Fig.1. Distorted Geometry Electromagnetic Energy-Density (field) functions (**EM_e** for $\mathbf{Fd}_{14}^2$ and **EM_mag** for $\mathbf{Fd}_{\text{mag}}^2$) for the BOSONIC-mediator structure, illustrating the ‘Strong-repulsive-force (is this [gluon](#) behavior?), Weak-force and Electric-force’ components. The ordinate in Joules/meter³ is displayed in logarithmic form and the abscissa in meters in logarithmic values.

From the “energy-emission dynamics” model in ref. [14], and using the “corrected form” of equations 11-15 (ref.[14] corrected in ref.[15]), we can model and calculate the “lifetime” of this boson-mediator structure as

$$t(\text{lifetime}) = \frac{1}{c} \left(\frac{3 U_0}{4\pi\rho} \right)^{1/3} = \frac{R_{\text{boson}}}{c} \stackrel{\text{def}}{=} \frac{1}{c} R_{0W} = 1.39 \cdot 10^{-27} \text{ seconds} , \quad (5)$$

where U_0 is the mass-energy of the “energy-emitting” body with a constant density ρ .

Environmental fields [16,17] not included in the structural modeling would influence this “lifetime” as, for example, the stability behavior of a neutron in or out of the presence of nuclear fields. This “energy emission” model is elaborated in the following for the “electromagnetic-radiation-emission mediator”.

Calculational Method for the Neutrino

The “extremum” equation (1) can be rearranged to accentuate the geometric-structural elements giving rise to the “strength of interaction” quantity GF as follows;

$$\begin{aligned} \mathbf{Fd}_{\text{mag}}^2 r^6 \pi^4 &= \frac{1}{8\pi\kappa} 2 R_s R_0^3 \pi^4 = \frac{\pi^3}{2} m_w c^2 R_{0w}^3 = \\ &\equiv \text{GF}(\text{distorted geometry}) \quad \text{or} \\ \frac{Q_w}{3 m_w c^2} S_w \frac{g_{e_w}}{2} &= \left(\frac{3 GF}{\alpha(\pi\hbar c)^3} \right)^{0,5} . \end{aligned} \quad (6)$$

We see then that the magnetic descriptors theoretically and mathematically allow for solutions describing extremum-structures other than the boson. If ascribed to a neutrino structure, the

extremum-structure would provide a magnetic characterization where, for example, using a neutrino mass [18-21] at 0.02 eV, an electric charge ($\neq 0$) is calculated at

$Q(\text{neutrino}) = 1.49(10)^{-12}$ (compared to $Q = 3$ for the electron or boson (see equation (2a)) or $Q(\text{neutrino}) = 7.46(10)^{-11}$ for a neutrino mass at 1.0 eV; such a charged neutrino structural description is presently not part of conventional modeling, ($Q = 0$), which however is experimentally not verifiable.

A structural configuration describing a “stable energy-density mimic of the electron” is described as

$$\frac{Q_{\text{neutrino}}}{3 (M_{\text{neutrino}} c^2)^{6/5}} \left(S \frac{g e}{2} \right)^{2/5} = \frac{Q_{\text{electron}}}{3 (M_{\text{electron}} c^2)^{6/5}} \left(\frac{1}{2} \frac{2}{2} \right)^{2/5} . \quad (7)$$

Such a “stable” structure would exhibit a charge Q at $3.87(10)^{-9}$ for a neutrino mass of 0.02 eV or $Q = 4.24(10)^{-7}$ for a neutrino mass of 1.0 eV.

Calculational Method for the Photon

In reference [14], we modelled “energy emitting structures” via a “black body construct” realized at the mass-level of a “fundamental particle” with a mass-energy = Universe-mass-energy. Here we posit such a “radiation-energy emitting” structure to describe photon emission. The Planckian (Stefan-Boltzmann emitting body) power and energy distribution function is integrated over the infinite energy spectrum and modelled as a spherical entity with radius R ;

$$P(\text{Planckian thermodynamics}) = \frac{dU}{dt} = -(\sigma T^4) A(r) \text{ and } A(r) = 4\pi R^2. \quad (8)$$

With

$$U = \text{the distortional mass energy @ constant density(?)} = \rho ,$$

$$\rho_{\text{geo_boson}} \stackrel{\text{def}}{=} \rho_{\text{GF}}(\text{DG}) = \frac{u_0 B^3}{\text{GF}} \left(\text{MW} \frac{\pi}{2} \right)^2 = 1.687(10)^{47} \frac{\text{J}}{\text{m}^3}$$

and

$$\text{Temp}_{\text{geo_boson}} = \left(\rho_{\text{GF}} \frac{c}{\sigma} \right)^{1/4} = 5.46 (10)^{15} K ,$$

leading to

$$\frac{dU}{dt} = -c(4\pi\rho)^{\frac{1}{3}}(3U)^{\frac{2}{3}} \quad \text{and}$$

$$U(t) = -\frac{4}{3} \pi \rho (c t)^3 + U_0 . \quad (9)$$

Using the radial-zero value, $u_0 B$, of the $\mathbf{F} \mathbf{d}_{\text{mag}}^2$ function, converts the normalization radius R_{0W} to its geometric value, $r = r_0$ since $u_0 B \equiv R_{0W}/r_0$.

A final extinction time, wherein all of the structural energy has been depleted and converted to photon-energy, is reached at

$$t_f = \frac{1}{c} \left(\frac{3 U_0}{4\pi\rho} \right)^{1/3} = \frac{R}{c} , \quad (10)$$

thereby producing a propagating directional photon (multi-particle production allowed) with a time-width t_f and inherited blackbody and DG features; we assume a photon with velocity = c and exhibiting the “thermodynamic” body descriptors; “thermodynamic radiation” being understood as “EM radiation” at velocity c . The use of an “explosive” adjective to describe this dynamic feature is better appreciated when examining the enormous energy-densities (10^{48} Joules/ meter³) or pressures (Pascals) within these “DG particle structures” (compare to a “stick of dynamite” at $\sim 10^9$ Pascals).

The extinction-time result can be interpreted as a “photonic-structural-descriptor” where

$$t_f \equiv 1/\nu \text{ and } R \equiv \lambda;$$

$$\lambda \nu = c ; \quad (11)$$

the thermodynamic variable c has an electromagnetic “velocity of propagation” meaning. Electric charge features are not inherent to this development since “black bodies” have been modelled from thermodynamics and statistical mechanics theory. This time-dependent feature of the proposed photon-mediator structure is only dependent on the DG geometric-radius feature R and not on the physical mass-energy features ρ and U (a simple conceptual model wherein “explosion-transition information” propagates physically throughout the exploding entity). The maximum-curvature DG-concept, from weak-force beta-decay modelling, produces a maximum energy limit at $R_{\min} = R0_W$, a charge-induced, magnetic-field- $(\mathbf{Td}_1^1 + \mathbf{Td}_2^2)$, r^{-6} , induced limit and therefore probably not the same limit as for $(\mathbf{Td}_1^1)$, r^{-4} , forces. In fact, the ratio of r^{-6} azimuthally-directed energy-densities to r^{-4} radially-directed energy-densities is

$$\frac{F_{d_{mag}}^2}{F_{d_1^2}} = \frac{8}{3} \left(\hbar c S \frac{Q}{3M} \right)^2 \frac{1}{r^2} = \frac{8}{3} \left(\hbar c \frac{1}{mW} \right)^2 \frac{1}{r^2} = 372 @ r = 0.5 R0_W. \quad (12)$$

The “material properties” of the “distorted-space” are sufficiently significant in the azimuthal directions as to be responsible for the phenomenon of beta-decay.

We consider therefore, the muon-structure (an excited electron-structure) as a black-body mediator-structure for “classical-radiation-emission”. Then

$$U_{\max_photon} = \frac{\hbar c}{R_{\min}} = \frac{\hbar c}{R0_{muon}} = 1.59 \cdot 10^{-10} \text{ Joules or } 1.23 \cdot 10^{-2} \times W_{boson} \text{ mass energy,}$$

where $R0_{muon}$ has been calculated from Eqn. (2a).

The DG muon-“photon producing”-mediator fields are displayed in Fig.2;

Fig.2. Distorted-Geometry Energy-Density (field) functions (E_{μ_e} for Fd_{14}^2 and $E_{\mu_{mag}}$ for Fd_{mag}^2), for the MUONIC-mediator structure, illustrating the ‘Strong-repulsive-force, Weak-force and Electric-force’ components. The ordinate in Joules/meter³ is displayed in logarithmic form and the abscissa in meters in logarithmic values. Note the energy-density reduction and the increase in radial extent compared to the W⁻ BOSON- character.

Although these distortional structures have been characterized at the outset as stable distortions, we have subsequently exploited the distortional form as the mediating entities in distortional transition processes, suggesting that the structural stability can be of a transient nature and sensitive to environmental “fields”. As a supplementary visualizing addition to the geometric modeling we include as a Supplementary Video an animated video (simulating the muon to electron beta-decay, a higher-energy nuclear process).

A black-body emitted, propagating, DG photonic structure is simulated and mathematically detailed, as an example, for the Lyman-alpha line @ $\lambda = 121.567$ nanometers (labelled $R0v$), in Fig.3; the simulation is also displayed in Fig.4 to better communicate the structure of the time-varying “energy-density fields”.

Fig.3. Distorted-Geometry-Photon Energy-Density (field) functions for the LYMAN-ALPHA_PHOTON ($\lambda = 121.567 \cdot 10^{-9}$ meters = $R0v$), illustrating the ‘Strong-repulsive-force, Weak-force and Electric-force’ components. The ordinate in Joules/meter³ is displayed in logarithmic form and the abscissa in meters in logarithmic values.

Fig.4. Distorted-Geometry-Photon Energy-Density (field) functions for the LYMAN-ALPHA_PHOTON illustrating the ‘Strong-repulsive-force, Weak-force and Electric-force’ components. The ordinate in Joules/meter³ is displayed in logarithmic form and the abscissa in

seconds in linear values. To emphasize the propagating energy, we have displayed the structural field character on a time scale. The actual time—extent of the photonic sphere (diameter at 2R) is double that shown in the core direction. Note the two physical-geometric facets of the Photon where $Ev_e = 0$ while $Ev_{mag} = Ev_{mag}(\max)$ and where $Ev_e = Ev_e(\max)$ while $Ev_{mag} = 0$, mimicking the behavior of an EM photon. The photon-frequency ν^{-1} condition occurs at the “extra-core” Ev_{mag} -maximum condition.

Calculational Method for the Gravitational mediator

The positive-pressure (positive energy-density) quantity, $(F_{d14})^2$, evaluated at the radius($r_{\max}$) of $(F_{d14})^2(\max)$, for the “HOLE_MIN” [13], GRAVITATIONAL STRUCTURE, due to a maximum curvature, is

$$\begin{aligned} F_{d14}^2(r^{-4} \text{ component}) &= \frac{Rs^2}{2} \frac{1}{8\pi \kappa G} \frac{1}{r^4} = \frac{(\kappa G Mg)^2}{4\pi \kappa G} \frac{1}{r^4} = \\ &= \frac{(\kappa G Mg)^2}{4\pi \kappa G} \frac{1}{(3.69 \cdot 10^{-3})^4} = 1.15 \cdot 10^{47} \text{ (Joule/meter}^3\text{)} @ r \equiv r_{\min} = 3.69 \cdot 10^{-3} \text{ meters} \end{aligned} \quad (13)$$

and where $\kappa G = G c^{-4}$ and $Mg = \text{mass of "HOLE MIN"} = 1.80 \cdot 10^{41} \text{ Joules}$.

The actual DG functional value at the energy-density maximum is $1.182 \cdot 10^{48} \frac{\text{Joules}}{\text{meter}^3} @ r = r_{\min} = 3.69 \cdot 10^{-3} \text{ meters}$, again illustrating the magnitude of the contribution to F_{d14}^2 from the r^{-6} and other r^{-n} components (see Fig.5).

Fig.5. Distorted Geometry Gravitational Energy-Density (field) functions $\mathbf{G_e} \equiv \mathbf{Fd_{14}}^2$ and $\mathbf{G_{mag}} \equiv \mathbf{Fd_{mag}}^2$, (for the “HOLE-MIN” structure $\equiv$ GRAVITATIONAL-mediator structure), illustrating a gravitationally-simulated ‘Strong-grav.-force, Weak-grav.-force and grav. r^{-4} -force’ components. The ordinate in Joules/meter³ is displayed in logarithmic form and the abscissa in meters in logarithmic values.

The positive-pressure (positive energy-density) quantity, $(\mathbf{Fd_{14}})^2$, evaluated at the radius of $(\mathbf{Fd_{14}})^2(\text{max})$, for the “Milky Way Black-hole” [13] GRAVITATIONAL STRUCTURE is

$$\begin{aligned} \mathbf{Fd_{14}}^2(r^{-4} \text{ component}) &= \frac{R_s^2}{2} \frac{1}{8\pi \kappa G} \frac{1}{r^4} = \frac{(\kappa G \text{ Mg})^2}{4\pi \kappa G} \frac{1}{r^4} = \\ &= \frac{(\kappa G \text{ Mg})^2}{4\pi \kappa G} \frac{1}{(1.34 \cdot 10^{10})^4} = 8.70 \cdot 10^{21} \text{ (Joule/meter}^3\text{)} @ r = 1.34 \cdot 10^{10} \text{ meters} \end{aligned} \quad (14)$$

and where $\kappa G = G c^{-4}$ and $\text{Mg} = \text{mass of Black Hole Sagittarius A}^* =$
 $= 4.154 \cdot 10^6 \text{ solar masses.}$

The actual DG functional value at the $\mathbf{Fd}_{14}^2$ energy-density maximum is

$8.95 \cdot 10^{22} \frac{\text{Joules}}{\text{meter}^3}$ @ $r = 1.34 \cdot 10^{10}$ meters , again illustrating the magnitude of the contribution to $\mathbf{Fd}_{14}^2$ from the r^{-6} and other r^{-n} components (see Fig.6).

Fig.6. Distorted Geometry Gravitational Energy-Density (field) functions $\mathbf{G_e} \equiv \mathbf{Fd}_{14}^2$ and $\mathbf{G_{mag}} \equiv \mathbf{Fd_{mag}^2}$, for the MILKY WAY Black-Hole, illustrating a gravitationally-simulated ‘Strong-grav.-force, Weak-grav.-force and grav. r^{-4} -force’ components. The ordinate in Joules/meter³ is displayed in logarithmic form and the abscissa in meters in logarithmic values. rMAX is the value of the radius at the Black-Hole maximum of $\mathbf{G_e} \equiv \mathbf{Fd}_{14}^2$.

Similarly, the negative-pressure (negative energy-density) core-maximum (for this black-hole gravitational structure) is

$$(\mathbf{Fd}_{grav\ core})^2 (\max @ r = 9.08 \cdot 10^9 \text{meter}) = -1.92 \cdot 10^{23} \text{ Joule/meter}^3. \quad (15)$$

Finally, a “gravitational representation” of the Fermi-constant, a maximum-curvature minimum-radius structure, can be calculated according to the Fermi definition as

$$\begin{aligned} \text{Gravitational interaction strength constant} &\equiv GG \equiv \frac{\pi^3}{2} m_G c^2 R_0^3 = \\ &= \frac{\pi^3}{2} m_G c^2 (\gamma^2 G c^{-4} m_G)^3 \text{ with } \gamma = \frac{3.275}{2} \text{ and} \end{aligned}$$

$m_G = \text{Black hole mass minimum [SI 4](as a mediator structure) , where}$

$$G c^{-4} = \text{gravitational coupling constant} = 8.26 \cdot 10^{-45} \frac{\text{meters}}{\text{Joule}} ;$$

$$GG = 3.22 \cdot 10^{35} \text{ Joule meter}^3 . \quad (16)$$

Conclusions

It has been shown in the present work that the distorted-space, or distorted geometry (DG), model of matter, as applied to fundamental-particle (boson, muon and gravitational) constructs, can produce structures satisfying “particle mass-energy-transition” or “mediator” dynamics. Earlier successful mimicking [11] of “Fermi-described beta decay” has been extended to a mediator description of “classical radiation-emission” and a “gravitational energy-transition mediator” entity.

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Supplementary Information is available for this paper.

Additional Information: Author Contribution Statement The work and representation was provided by the sole author

Competing Interests There are no competing interests for this paper

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SI Supplementary Information

Supplementary Equations

GEOMETRIC MEDIATOR STRUCTURES AND FORCE CONSTANTS

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For the presently described spherically symmetric Maxwellian case, ϕ , the electrostatic potential, is a function of r alone, and the Maxwellian electromagnetic tensor and the associated field tensor $\mathbf{F}_{1\mu}$ can be constructed according to equation (SI-1), where the only surviving field tensor components are (following the symbolism and development of Tolman [SI-1]):

$$ds^2 = g_{11}[dr^2 + r^2 d\Omega] + g_{44}dt^2 = -e^\mu[dr^2 + r^2 d\Omega] + e^\nu dt^2,$$

$$\mathbf{F}_{21} = -\mathbf{F}_{12}, \mathbf{F}_{13} = -\mathbf{F}_{31} \text{ and } \mathbf{F}_{14} = -\mathbf{F}_{41}, \quad \text{i.e.}$$

$$\mathbf{T}^{\mu\nu} = -\mathbf{g}^{\nu\beta}\mathbf{F}^{\mu\alpha}\mathbf{F}_{\beta\alpha} + \frac{1}{4}\mathbf{g}^{\mu\nu}\mathbf{F}^{\alpha\beta}\mathbf{F}_{\alpha\beta} \quad \text{or} \quad \mathbf{T}^{\mu\mu} = -\mathbf{g}^{\mu\mu}\mathbf{F}^{\mu\alpha}\mathbf{F}_{\mu\alpha} + \frac{1}{4}\mathbf{g}^{\mu\mu}\mathbf{F}^{\alpha\beta}\mathbf{F}_{\alpha\beta}, \quad (\text{SI-1})$$

then

$$\mathbf{T}_4^4 = \frac{(\mathbf{F}_{12}\mathbf{F}^{12} + \mathbf{F}_{13}\mathbf{F}^{13} - \mathbf{F}_{14}\mathbf{F}^{14})}{2}, \quad \mathbf{T}_1^1 = \frac{(-\mathbf{F}_{12}\mathbf{F}^{12} - \mathbf{F}_{13}\mathbf{F}^{13} - \mathbf{F}_{14}\mathbf{F}^{14})}{2},$$

$$\mathbf{T}_2^2 = \frac{(-\mathbf{F}_{12}\mathbf{F}^{12} + \mathbf{F}_{13}\mathbf{F}^{13} + \mathbf{F}_{14}\mathbf{F}^{14})}{2} \quad \text{and} \quad \mathbf{T}_3^3 = \frac{(\mathbf{F}_{12}\mathbf{F}^{12} - \mathbf{F}_{13}\mathbf{F}^{13} + \mathbf{F}_{14}\mathbf{F}^{14})}{2}.$$

The resultant field quantities are

$$(\mathbf{F}_{14})^2 = -(\mathbf{T}_4^4 + \mathbf{T}_1^1)\mathbf{g}_{11}\mathbf{g}_{44} = (\mathbf{T}_2^2 + \mathbf{T}_3^3)\mathbf{g}_{11}\mathbf{g}_{44},$$

$$(\mathbf{F}_{12})^2 = -(\mathbf{T}_2^2 + \mathbf{T}_1^1)\mathbf{g}_{11}\mathbf{g}_{11} \quad \text{and} \quad (\mathbf{F}_{13})^2 = -(\mathbf{T}_3^3 + \mathbf{T}_1^1)\mathbf{g}_{11}\mathbf{g}_{11}.$$

Therefore, we see that the static-spherically-symmetric Maxwellian tensors exhibit the same stress and energy relationship as the geometric tensors [SI-1],

$$\mathbf{T}_4^4 = -(\mathbf{T}_1^1 + \mathbf{T}_2^2 + \mathbf{T}_3^3). \quad (\text{SI-2})$$

The present geometric-modeling endeavor, with its Maxwellian-tensor-form mimicking-component, has produced the fundamental and limiting agent for the currently-studied distorted geometry, namely a particular constraining functional relationship between the geometry-defining tensors (for an empty-space geometry, all of the components of the energy-momentum tensor are zero). In using this simple equation-of-state, equation (SI-2), as a restricting distortional-model tensor relationship, we thereby elicit the metric-defining differential equations for such a family of geometric distortions.

The geometric-energy-density or field equations, after using solution Eq. (SI-4), are repeated here (from [SI_2]); also see [SI_1];

STRUCTURAL EQUATIONS

The calculational treatment employs the isotropic coordinate description of equation (SI-1) and utilized by Tolman [SI-1], where the system of equations represented by equation (SI-1), is shown more explicitly in equation (SI-3) in mixed tensor form;

$$\begin{aligned}
 8\pi\kappa T_1^1 &= -e^{-\mu} \left[\frac{\mu'^2}{4} + \frac{\mu'\dot{v}}{2} + \frac{\mu'+v'}{r} \right] + e^{-v} \left[\ddot{\mu} + \frac{3}{4}\dot{\mu}^2 - \frac{\dot{\mu}\dot{v}}{2} \right], \\
 8\pi\kappa T_2^2 &= -e^{-\mu} \left[\frac{\mu''}{2} + \frac{v''}{2} + \frac{v'^2}{4} + \frac{\mu'+v'}{2r} \right] + e^{-v} \left[\ddot{\mu} + \frac{3}{4}\dot{\mu}^2 - \frac{\dot{\mu}\dot{v}}{2} \right] = 8\pi\kappa T_3^3, \\
 8\pi\kappa T_4^4 &= -e^{-\mu} \left[\mu'' + \frac{\mu'^2}{4} + \frac{2\mu'}{r} \right] + e^{-v} \left[\frac{3}{4}\dot{\mu}^2 \right], \\
 8\pi\kappa T_4^1 &= +e^{-\mu} \left[\dot{\mu}' - \frac{\dot{\mu}\dot{v}'}{2} \right], \\
 8\pi\kappa T_1^4 &= -e^{-v} \left[\dot{\mu}' - \frac{\dot{\mu}\dot{v}'}{2} \right]. \tag{SI-3}
 \end{aligned}$$

Metric coupling, that is terms such as $\mu'v'$, are apparent in the fundamental curvature equations. The usual notation, where primes denote differentiation with respect to the radial coordinate r and dots denote differentiation with respect to the time coordinate t , is employed. We are considering the static case (where total differentiation replaces partial differentiation) as was also used for Schwarzschild's (gravitational) interior and exterior solutions for the model of an incompressible perfect-fluid sphere of constant density surrounded by empty space [SI-1]. In that work a zero-pressure surface-condition and matching and normalization of the interior and exterior metrics at the sphere radius were used as boundary conditions.

Tolman [SI-1] has shown that the energy of a “quasi-static isolated system” can be expressed as “an integral extending only over the occupied space”, which we will allow to extend to infinity, and where the total energy of such a sphere is therefore expressed as

$$U(\text{sphere total}) = \int_0^\infty (T_4^4 - T_1^1 - T_2^2 - T_3^3) \sqrt{(-g_{11})^3 g_{44}} 4\pi r^2 dr = M_{\text{sphere}} c^2.$$

This mass-energy representation will be used throughout in calculating the distortional mass-energies. The distortional-tensor energy-density amplitudes manifested in these presently calculated geometric representations are both negative and positive, that is, there are both negative energy-density [SI-2] and positive energy-density regions internal to the distortions. However, the modeled distortions for the mimicked elementary particles all exhibit positive

mass-energies. Since geometric distortional fields arise from the same energy-density tensors, the negative energy-density geometric regions are also sources of negative energy-density field quantities.

$$\mu' = \frac{2(1-u^3)u^2}{(Iu-\gamma)R0}, \quad u \equiv \frac{R0}{r}, \quad (\text{SI}_4)$$

(R0 is the normalizing radius after mimicking EM and gravitational forces)

$$Iu = -u \left[\frac{3}{7}u^6 - \frac{3}{4}u^3 + 1 \right],$$

$$8\pi\kappa \mathbf{Td}_1^1 = -e^{-\mu} \frac{1}{(Iu-\gamma)} \left(\frac{u^2}{R0} \right)^2 \left[2u^2 + (3u^3 - 1) \frac{1-u^3}{(Iu-\gamma)} \right],$$

$$8\pi\kappa \mathbf{Td}_2^2 = e^{-\mu} \frac{1}{(Iu-\gamma)} \left(\frac{u^2}{R0} \right)^2 \left[4u^2 + (3u^3 - 1) \frac{(1-u^3)^2}{(Iu-\gamma)} \right],$$

$$8\pi\kappa \mathbf{Td}_4^4 = -8\pi\kappa (\mathbf{Td}_1^1 + 2\mathbf{Td}_2^2) \quad \text{since} \quad \mathbf{Td}_3^3 = \mathbf{Td}_2^2$$

or

$$\mathbf{Td}_4^4 = e^{-\mu} \frac{1}{8\pi\kappa(Iu-\gamma)} \left(\frac{u^2}{R0} \right)^2 \left[-6u^2 - (3u^3 - 1) \frac{(2u^3 - 1)(u^3 - 1)}{(Iu-\gamma)} \right]$$

$$\text{and} \quad 8\pi\kappa (\mathbf{Td}_2^2 + \mathbf{Td}_1^1) = e^{-\mu} \frac{1}{(Iu-\gamma)} \left(\frac{u^2}{R0} \right)^2 \left[2u^2 - (3u^3 - 1) \frac{(1-u^3)u^3}{(Iu-\gamma)} \right]$$

leading to

$$(\mathbf{Fd}_{14})^2 = -g_{11}g_{44}(\mathbf{Td}_4^4 + \mathbf{Td}_1^1) = g_{11}g_{44}(2\mathbf{Td}_2^2) \quad \text{and}$$

$$(\mathbf{Fd}_{14})^2(r \rightarrow \infty) \stackrel{\text{def}}{=} \left(\frac{Rs}{2} \right)^2 \frac{2}{8\pi\kappa} \frac{1}{r^4} = \frac{Rs^2}{2} \frac{1}{8\pi\kappa} \frac{1}{r^4} \stackrel{\text{def}}{=} \left(\frac{q}{4\pi\epsilon_0 r^2} \right)^2 \frac{\epsilon_0}{2}.$$

$$(\mathbf{Fd}_{12})^2 + (\mathbf{Fd}_{13})^2 = 2g_{11}g_{11} \left(\frac{\mathbf{Td}_4^4 - \mathbf{Td}_1^1}{2} \right) \stackrel{\text{def}}{=} \mathbf{Fd}_{\text{mag}}^2 =$$

$$= -2g_{11}g_{11}(\mathbf{Td}_1^1 + \mathbf{Td}_2^2) \quad \text{and}$$

$$(\mathbf{F}\mathbf{d}_{12})^2 + (\mathbf{F}\mathbf{d}_{13})^2 (r \rightarrow \infty) = 2 R_s R_0^3 \frac{1}{8\pi\kappa} \frac{1}{r^6} \stackrel{\text{def}}{=}$$

$$\stackrel{\text{def}}{=} \frac{\mu_0}{2} \left(\frac{\mu_{spin}}{2\pi} \right)^2 \frac{1}{r^6}$$

where

$$\mu_{spin} \stackrel{\text{def}}{=} \left(\frac{g_e Q e}{2 3M} \right) S \hbar \quad \text{and} \quad g_e = 2.00231930436 \text{ (for the electron) .}$$

The **Td** and **Fd** symbolism is used for the “distorted geometry” tensor quantities. The field equations, in both the EM realm and the gravitational realm ($Q = 0$), exhibit r^{-6} geometric behavior which we have interpreted as constituting a “magnetic monopole” mimic (what is a “magnetic monopole”?).

A 2-dimensional plot of this structure is included here to help visualize the “distorted-geometry” model.

Figure SI-1 Mass-Energy-Density distribution-function surface-plots (two views) (linear radii and logarithmic amplitudes) for the geometric hole distortion.

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SUPPLEMENTARY VIDEO

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As a supplementary visualizing addition to the geometric modeling we include as a

Supplementary Video an animated [muon video](#) file, or `geo-muon decay.avi` (simulating the muon to electron beta-decay, a higher-energy nuclear process), produced as a spherically symmetric representation with the following details:

frames 0-15; geometric-distortion mass-energy-density function for muon,

@ frame 15, “muon” transitions (morphs) to “W boson”, and

@ frame 30-45, “W boson” transitions (morphs) to “electron + neutrinos”;
neutrinos not displayed.

The beta-decay animation is constructed with linear radii but with logarithmic amplitudes and logarithmic normalizing radii R_0 and is further normalized to a “neutrino” amplitude and an “electron” radius.