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Gravity: Where Quantum Physics and Classical Physics finally merge

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ABSTRACT

In this 3rd paper of a triptych on quantum theory regarding gravity, quantum, and classical physics are merged seamlessly-however with conclusions deviating from classical physics regarding singularities, space-curvature, and graviton. Mathematically, singularities (Schwarzschild, Droste) vanish by proper definition of the gravity source and field descriptions acquiring full validity at the Planck scale. Space(-time) curvature is shown to be geodesic-trajectory curvature by (energy) objects in the field of (a) gravity source(s). The gravity field is found to be a scalar field in which the trajectories are defined only by the principle of least action (LaGrange, Feynman) by compensation of accelerations due to different physical causal sources of acceleration. The graviton is argued to be a massive Higgs-type scalar boson with ubiquitous presence since the creation of quantum and clustered mass in the universe: the influence of a settled gravity field on mass (in) entering this field, therefore, is instantaneous, i.e., unlike a vector boson description. Gravity waves, occurring in mergers/transitions of mass, are defined by changes in time of the gravity field (at max. c m/s) in space and only become observable when substantial mass/energy is involved due to the weakness and spatial decay of gravity fields. All mathematics (e.g. integral transformations, vector space, etc) and related operators in the paper are part of the Abelian group for validity at the Planck scale. Results thus constitute the description of gravity on all scales.

Keywords: Curvature, quantum, classical, Abelian, Singularity

INTRODUCTION

Consistent descriptions connecting the results of Einstein's tensor treatment of gravity in general relativity with quantum physics have not surfaced despite major efforts in e.g. string theory, brane theory, manifold descriptions, holographic scenario's, entropic force proposals as well as attempts in mathematical non-Abelian groups and more.
The classical approach in strong gravity fields i.e. massive objects e.g. black holes, is to describe trajectories on surfaces by Killing-vectors (Wilhelm Killing, Germany) and vector fields as tensor metrics on a manifold. This approach e.g. often uses Lie algebras and matrix mechanics which both pose substantial restrictions in the use of these mathematics when this description is to remain valid in the quantum realm. Furthermore, the use of Killing vectors for descriptions of e.g. scalar fields is not found to required, even when the fields originate from vector fields.
The derivation by both K. Schwarzschild [1] and J. Droste (1916) [2] of the field of gravitation and particle motion is a most ingenious as well as elaborate, however cumbersome trajectory (in the meaning of difficult to handle or to take into a separate domain for near- and far-field description) to exact solutions of the Einstein tensor analysis, and seems directed

to planetary motions and its corrections. It e.g. is including non-Abelian matrix mechanics and non-symmetrical (far-) field approximations with many substitutions and as well yields singularities where they do not exist e.g. possibly introduced by multiple substitutions of variables in the mathematics of the field descriptions (Gravitational Potential, The Black Hole Horizon). Terms in equations with $1/r$ may indicate curvature domain i.e. in a field description indicating zero curvature for $r \to \infty$ i.e. m (test mass) outside the field or in extreme weak field of M, which points at variable validity violation as well, or as J. Droste [2] phrased it in his 1916 paper (endorsed by H. Lorentz): "this variable r is not the same as occurs in (4)".

In classical physics the result is considered exact, however from quantum mechanics (QM) perspective, the Planck scale behavior (near zero, curvature, singularities) and the non-Abelian mathematics (even only partially), don't acquire full validity on this scale; and when with non-commutative operators in descriptions, a different approach is required. This prompted the (Poisson related) direct scalar potential approach taken into the complex vector space and Green's function-based system-model as a new starting point and a description of quantum gravity is given bottom up from potential theory of the scalar potential $\Phi(r)$ for validity at the Planck scale. A quantum mechanical description of gravity then is proposed as a causal relation in the natural and transformed domains by the curvature as frequency-intensity parameter i.e. the integral transformed (k, r) domain. In this domain mathematically exact result functions in quantum system causality descriptions can be derived instead of statistical probability functions, e.g. as outlined and illustrated in [3, 4], the first two articles of the triptych. Therefore, all-natural domain mathematical (r, t) descriptions resulting in expectation values in a statistical, or non-Abelian group treatment are not suitable for exact results in QM. Mass, causing curvature by gravitation is modeled by the frequency ($1/r$, at location) of curvature occurrence at location r i.e. in the (k, r) domain.

The circle frequency $\kappa = 2\pi k(r)$ with $k(r) = 1/r$. In contrast with treatment in the natural (r, t) domain, prone to mathematical and in (experimental) reality physical collapses with expectation values, the descriptions in the transformed frequency domain do not violate uncertainty relations in quantum properties and retain full validity in the space domain, detailed in [3].

In the treatment on quantum scale, stringent conditions apply in the mathematical structure at the current local energy level: the theory is formally restricted to Abelian groups (Nils Henrik Abel, 1802-1829, Norway; Mathematician) e.g. algebras, operators, vector + scalar- spaces, -fields and requires operator commutativity, a fundamental condition. Where a classical approach top-down is used for a mathematical description in the quantum realm, the mathematics therefore must be validated for compliancy. Mass is considered a property of a quantum or classical object. On quantum scale, creation of mass is on a much higher energy level and is caused by (spontaneous) symmetry breaking [5, 6] resulting in status quo states at lower energy level. Generation of mass is manifest by a Higgs' (type) boson coupling to other elementary particles e.g. quarks, resulting in mass of elementary quanta i.e. the source of a gravitation field distributing in space. This field as function of location settles in space at max. c m/s. Matter then is the result of concentrations of elementary particles of energy as result of coupling and forming elementary quanta with mass, accounting for mass -density and -dimension at quantum scale. Although the creation has taken place at much higher average energy levels than in the universe currently, this level had to be achieved in experiments (LHC) with proton experiments being carried out to find the Higgs' particle. The found 125GeV is established as the value to acquire mass of the proton, consisting of three quarks; less massive fundamental particles may require less energy, i.e. more Higgs'-type particles may exist. The creation of mass on quantum level in the model then is taken as a system source that interacts (couples) via a Higgs' mechanism-function as cause, resulting in a massive elementary particle. The mass generating effect for elementary particles resulted instantly in gravity potentials around them and in different local conditions, chemical elements and matter could be created at suitable energy levels. The basis of the quantum gravity field then is identified in two vector-fields, and from these fields, in pairs of vectors for locations in space, a gravity source description with pre-determined field strength by inner vector (i.e., scalar) product is derived. Gravity thus is considered to evolve in space in a causal system-theoretical description i.e. then constitutes the description of gravity effects in space starting from quantum sources.

Top-down, this paper takes the classical results of Einstein's relativity theory-based tensor solutions of the Schwarzschild radius as starting point i.e. shown in the derived identical curvature results; then treats singularities upscaled, in general avoiding algebraic associations with variables addressing individual quanta i.e. quanta in curved space or manifolds directly or by integral domain transformation. In [4] is argued that individual quantum behavior remains hidden from observation or measurement and this includes for example degrees of freedom or internal energy of quanta. Side-effects and other indirect information of experiments can be gathered to reveal quantum behavior, e.g. propagation of quanta in materials [4], and LHC high energy experiments. This treatment of gravity does not provide support for the hypothesis of the occurrence of (naked) singularities in large enough massive objects, nor in the abstract point-source of mass (see System Sources) with a field of gravitation around it; the generic results are as well independent of (properly defined) coordinate systems.

THE HIGGS(-TYPE) BOSON

The Higgs' boson has been predicted since 1961 by Higgs [5], Brout and Englert [6]; as a free detectable particle has an extreme short time to live at current energy level. Experiments with the LHC in 2012 revealed the existence of particle (energy app. 125 GeV) and the achievement is being regarded a formidable breakthrough. The Higgs' field is considered to have a permanent ubiquitous invisible presence in nature; however, this starting point does not identify a cause (source) for the field. A source should be right at the basis of a spatial field distribution and 'no-source' is postulated not being in line with the fundamental causal evolvement of (events in) nature. The obvious source is the 'big bang' in which the distribution of energy and consequently of mass quantum particles likely was far from uniform. Mass can be regarded as an energy state of e.g. concentrations Higgs' coupled elementary particles leading to e.g. protons at the energy level to form nuclei and to other Higgs' type particles in less massive quantum elementary particles, the basis for different types of matter. Where concentrations and energy levels were favorable enough, currently visible matter has been created, estimated around 5% of total mass in the universe. Assuming that 100% of quantum mass has been created during the 'big bang', then 95% would have been around still in quanta, at creation less concentrated and without favorable conditions to start forming elements, and not ever aggregating anymore at current energy level and scale in 'empty' space. The assumption is that on quantum level, once a boson couples to form standard model elementary particles with mass, with all the generated entities/particles instantly gravity fields were created, and matter and gas clusters could be formed with elementary particles at locations where concentration and energy levels were favorable. The gravity field generated from the Higgs' field(s) filled space at max. c m/s, i.e. each coupled Higgs' boson is a source of mass generation by interaction, and the therewith created gravity field distributes instantly in space. The total energy of the massive particle is contained in the field and mass of the particle, the field decaying with distance, and the total energy is limited to the Higgs' energy or less when other less massive elementary particles are created. Its maximum field value is assumed to be located in the center in free space directly at the surface of the Higgs' coupled (dimensional) particle, and decays losing density by expansion on a spatial spherical surface. As the Higgs' mechanism interacts with elementary particles acquiring mass, which particles make up elementary SM particles, quantum gravity sources therefore consist of discrete quantum masses i.e. mass as property in matter is quantized. This applies to the total particle energy value of mass and field. The field strength represents the potential energy as function of the dimension r in space i.e. by dimension is not quantized. The potential field on quantum level reacts identical as argued (see Gravitational Potential, massive black hole M), by storage of the energy of an external particle m_1 entering and moving in the field with a velocity component in the direction of the source m_0, meaning that energy is given to the particle and vice versa. There are 3 options;

1) the particle escapes by taking a trajectory escaping the source, returning the taken field energy of the conservative field, or

2) interacts, meaning that all of its own energy + the energy taken from the field are coupled to form a massive particle, illustrating energy exchange i.e. the interaction of the potential field and mass on quantum level.

3) The third option of orbiting by gravity is rejected due to the weak quantum gravity fields and required extreme curvature value required at the Planck scale, and a much stronger force is required to allow orbits at this scale, i.e. obviously the electromagnetic force between protons and electrons.

The foregoing fundamentally means that the gravity mechanism is valid at extremely different scales: the potential field (temporarily) loses energy and gains the same amount later-on by particles or massive objects, when not aggregating at quantum level or merging with e.g. a black hole.

An established interpretation in quantum physics is that the particles are a manifestation of excitations of a (Higgs') field in the structure of / with other particle fields, and a more classical view is that the Higgs' particle interacts with other standard model particles to provide mass in building blocks of matter, while in this paper the cause = boson coupling status quo as the source, and the effect c.q. result = mass + gravity field i.e. a fundamental causality relation in a system-theoretical, description is proposed. After [3] and [4], this is the 3rd paper of the triptych in quantum mechanics, a quest researching an entirely different mathematical description from the usual wave function model to arrive at a deterministic and complete theory in quantum mechanics. The system theoretical approach therefore fully contrasts with the unitarity of the Schrödinger wavefunction of Hamiltonian evolution of quantum states, as it transfers the evolution of cause and effect mathematical (r, t) relations into the integral transformed domains leading to exact functions instead of probability relations: the basic reason to explore and use different mathematics in quantum physics e.g. in gravity as presented here. The curvature frequency domain description exceptionally well suits quantum behavior by exclusion of direct addressing individual quanta with variables, as well as by providing validity of variable r throughout the entire range in gravity, by the a priori mathematical exception of the location of a point-source at $r = 0$; two solutions are provided to solve the issue of (naked) singularities and to acquire full validity of the variable.

This approach increases the distance to-and minimizes anomalies-in the sense of peculiar results (because of interpretations). In the 2nd paper [4] of the triptych, information is considered 'ordered' energy (that may become fully dis-ordered e.g. in a black hole), arguing that 'information' only can be contained/preserved in some form of memory i.e. atoms, molecules, DNA, (human) brain, books, computer chips etc. as argued in [4], taking away the sting of the information paradox in black holes. Whichever interpretation is the right one, in this system model of quantum causal relations is not an issue [4], as in the invisible reality of quanta, the energy and transitions of individual quantum particles cannot be observed (quanta remain 'invisibles' with regard to their original state) i.e. the description of the phenomena is hypothetical and based on thought experiments and assumptions, abstracted in the mathematics, and is to be verified by experiment.

Quantum behavior thus is described in systems-theory [7-9] by a source and a result function in a causality description which identifies this relation only by cause- and effect-functions (system input-output relations). This paper thus fundamentally considers Higgs'-type bosons as the causal quantum of mass, and assumes spatial dimensions at the

Planck scale i.e. in the standard model SM. The Higgs'' type boson coupling creates mass and field, manifest in a natural domain. A transform of the mathematical description into the transformed domain [7, 10], yields quanta-based mass distributions in the frequency (k, r) domain, valid in space as in classical physics. Then results finally link with the results of Einstein's tensor-analysis of gravity. First, attention is being paid to the standard model.

THE STANDARD MODEL & DIMENSIONS

Mass of fundamental particles of the standard model (SM) e.g. an electron or a neutron, is accepted as a property, without a definition in space apart from location. Standard model particles are usually considered as entities without dimension, which - as in this paper is assumed-is a drawback of the model occasionally. Therefore, as a starting point of the description, elementary particles are not regarded dimensionless and are considered in reality to 'take up some amount of space', i.e. in a 3-dimensional (3D) description. A second reason for 3D is that gravity does not give rise to very dynamic events at quantum level requirering a mandatory 'spacetime' fundamental description of the nature of gravity. At current energy level quantum gravity dynamics are low, however in (very large scale) galaxy centers of extremely large black holes and mergers of large massive objects, this requirement changes. However, the vectors in definition of the source of the gravity field can be complex, therefore e.g. phase-differences of the field relative to a source when required can be accounted for, e.g. with local time as parameter (when not yet defined and implemented as a true dimension). Three dimensions in order to expand, or rather shrink, i.e. define dimensions in the quantum realm are in this paper fundamental to be described mathematically in emergent gravitational fields from QM-perspective. As a consequence, the property 'mass' is to be described in terms of mass-density i.e. specific mass property with a volume, surface or line-curve in a dimensional description. For quantum particles in the standard model in 3D-space, the description of mass m is substituted with a product of specific-mass m_s (kg/m^3) mass density and its dimensional volume $V(m^3)$, i.e. $m = m_s V$ (kg) as treated in Field Descriptions. This at first sight does not seem to have substantial impact in the SM or in classical physics where a massive object is characterized with mass M, however has the effect of fundamentally changing the perspective in physics as dimensions are embedded on all scales of the description.

FIELD DESCRIPTIONS

An electromagnetic description requires 2 fields in a vector environment of E and H i.e. both with attracting and repelling components and both have direction and magnitude and as well include potential E-field theory (showing the brilliance of J.C. Maxwell). This is mandatory in EM fields as energy transport is required to be described (i.e. RH system with Poynting vector in classical EM theory and by a vector gauge boson in the SM). A description of gravity in a unified field theory (UFT) therefore fails in case the field of gravity is a scalar field: it does not (need to) transport energy to be converted at large distance, only conserves and returns energy and with 1 component of mass is attractive only. Gravitons as carrier of a gravity force in analogy with photons of the electro-magnetic force, thus never have been found. A deviating hypothesis for the influence of gravity in space is postulated by identification two basic fields in (complex) vector space with a resulting field manifest with scalar complex field strength values of the potential conservative field, illustrated by a non-rotating, non-charged black hole. By introduction of mass density in the dimensional description in the Standard Model - to explore very small or even quantum black holes-mass density would have to be extreme i.e. beyond limits of required energy of creation to be supported and is therefore rejected: from eq. (4) and eq. (11) follows $m_{DS} = 3c^4/(16\pi G a_s {r_s}^3)$, with a_s acceleration at Schwarzschild radius r_s (order of magnitude $r_s \sim 10^{-35}\, m$), m_{DS} specific mass of quantum, c (m/s) vacuum speed of light. The obvious conclusion is: black holes only exist at star scales. The black hole then is a massive object not 'radiating' other energy than its established field of gravitation (except Hawking radiation; which is not considered to influence a semi-static model and is neglected), and has restricted energy transport capabilities. In a description of transporting force-fields, a carrier boson is required as the transported energy may be used in transformation of energy far away from the source e.g. for recovery of information i.e. ordered energy or in strong fields, e.g. lightning strikes. The black hole has a gravity field attracting mass in space and therefore is not truly black with respect to mass and gravity, meaning that an energy exchange i.e. temporary energy transport exists between the massive hole and mass particle. Obviously, this cannot be of em-nature radiated from the hole, and with the gravity field attractive for all types of energy, the energy is contained as well in the gravity field outside the massive object core as a direct function of its mass M.

This field therefore is capable of restricted exchange of energy with particles having mass or energy (equivalence relation), leaving a particle in the field with only 3 options: it can escape the source M, is attracted with motion towards the hole in the entire trajectory and collides with M, or the particle can orbit a massive black object. In case it escapes, as soon as distance to the hole increases, it returns the field energy it gained in reducing distance and when captured, all of its energy including the gain from the field is delivered to the hole i.e. the field energy is returned and by increase of captured mass in the core, also the total energy (and horizon) of the hole increases. For photons in the field of a massive object, with constant $v = c(m/s)$, this means a change of wavelength in mass equivalent energy h.v i.e. uv-shift in approaching M and red-shift when distance to M increases; for an observer of an image of the 'lensing' effect, the shifts are not observed as energy is exactly returned. In case of a black hole the temporary lost energy cannot be compensated by em-radiation. The conclusion therefore is that the energy temporary must be delivered by motional changes, the momentum or by rotation; the hole experiences a tiny force by acceleration of the field of m in the direction of m, which is more obvious to an observer when m is in the order of magnitude of M: the field is able to re-actively exchange energy i.e. a conservative potential field.

ACCELERATION AND FORCE

The field of acceleration usually is considered to be the cause of 'action at a distance' by gravity; geo-metrically the field strength values at a location r derived on quantum scale in the qm-perspective are pre-determined in an acceleration field, i.e. locally the field strength is determined in space and the field values are the manifestations of the established field where local mass is present, thereby mediating the gravity force F_G experienced by mass at the particular location. The acceleration vector field however is argued in the Gravitational Potential not to be the source field of gravity. Still, the force of gravity is not 'carried' but is truly 'mediated' on a local mass property in space i.e. the boson-coupling in local mass m with the local field strength fundamentally results in the local gravity force F_G on mass, and is manifest as force directly after the fields of M and m are established in space, which is assumed for both m and M to distribute directly after mass creation at quantum level. The 'graviton' as quantum of gravity thus constitutes a mediating boson type.

Particles have different masses and may require different coupling energy; therefore, it cannot be excluded that several types of Higgs' bosons exist, and if so, all with mass. Higgs' boson: $E = h\nu = 125\ GeV$, equivalent mass $125 GeV/c^2$; the energy value is relatively high as it provides the energy to create mass of elementary particles e.g. of quark-composite protons in the LHC experiments. As the gravity field cannot act as fundamental source of energy, the energy only in restricted way can be transported by the field (although astronomy reports have been made interpreting energy transport by gravity fields by assumed loss of energy in interactions of heavy objects); comment author: (free, independent) transport may be a wrong description; conserved potential field energy in the strong gravity fields converting into kinetic energy FdS of motion may be a consistent explanation; gained energy from the field is temporary and is returned. The field is conservative i.e. gravity 'uses' mass and field to exchange energy and the trajectory closed integral in the end equals zero: $\int_c F.dS = 0$.

The property to exchange re-actively and locally internal energy of the potential field is of major importance in (quantum) physics, for example in local temporal energy exchange with photons enabling propagation in materials [4].

The gravity force F_G thus is a fundamental force manifest by a potential field strength of acceleration magnitudes of a quantum gravity source, and is the one (and only) force with the most significant visible impact in the universe, and unlike other fundamental force-vector fields, the quantum boson is a mediating scalar boson, i.e. F_G is not being 'carried' by a vector boson. The gravity potential field thus acts as an acceleration scalar field, and this is because matter consists of two inseparable components of energy: mass and field. The cause (coupling of Higgs' boson presence in SM elementary particles and matter) of the potential field is a reality description, as gravity then clearly is emergent from concentrations of standard model elementary particles coupled to Higgs' type bosons, as well is consistent with a gravity forces' full causality description by geo-metrics only, at all quantum short and classical long range distances i.e. in a gravity field instantly resulting in a force on local matter/mass, thereby providing as well the link with the classical Einstein tensor-analysis results as well as the conclusion of a massive graviton boson.

GRAVITATIONAL POTENTIAL

A potential at a certain location in space may be used to exchange energy in case the field of potentials has a rate of change in space. The affected energy is related to the property of the field i.e. electrical, gravitational. A mathematically proper description of a potential field is derived from potential-theory, taken into a vector space description and is started with a point source; a further step is illustrated by the introduction of dimensional mass of certain volume and density as realistic source. For an energy description on quantum level, our interest is thus in the decaying rate of the potential field as a function of vector $\boldsymbol{r}$, having magnitude and direction i.e. the vector field partial derivatives in space of a quantum mass source. The gravitational potential Φ of a differentiable scalarfield function of a symmetrical $3D$ entity with mass M is given by protentional theory,

$$\Phi(r) = \frac{GM}{r} \tag{1}$$

The description is in magnitudes without sign; the directions become clear in the vector field description. To observe the change of the potential vector field in a direction in space, i.e. the (∇) Nabla operator represents the partial differentials in vector space: $\nabla = \left(\frac{\delta}{\delta x}\right) i + \left(\frac{\delta}{\delta y}\right) j + \left(\frac{\delta}{\delta z}\right) k$, resulting in the corresponding vector field $\nabla.\Phi(r)$ [11], i.e. acceleration field $a_G(r)$,

$$a_G(r) = \nabla.\Phi(r) = \nabla.\left(\frac{GM}{r}\right) = GM\frac{\boldsymbol{r}}{r^3}$$

or

$$a_G(r) = GM\left(\frac{\boldsymbol{r}}{r}\right)\left(\frac{1}{r^2}\right) \qquad \text{for all r > 0} \tag{2}$$

With ∇ the Nabla operator, $\boldsymbol{r}$ the position vector, $\boldsymbol{r}/r$ unity vector, $\Phi(r) = GM/r$, G the gravitational constant, M the (point-)source of the potential field.

Nothing new under the sun, however (2) is started in vector space and the derivation is to be formally completed in the vector space, basically by respecting the cause-and-effect relations: source is the settled field of M providing acceleration values, resulting in the acceleration vector field leading to the force on m in direction of the origin of $\boldsymbol{r}$ i.e. in the source. The result is a vector inner product.

Equation (2) identifies the gradient of the vector field which physically is the change rate of potential Φ in the direction of vectors $\boldsymbol{r}$.

The force F_G exerted by the field on a test mass m then is $mGM\left(\frac{\boldsymbol{r}}{r^3}\right) = ma_G(r)$.

The description is finalized in the vector space by facilitating the acceleration $a_G(r)$vectors as mediator of the gravity force experienced at r in the opposite direction of unit vector $\boldsymbol{r}/r$, by means of the dot (inner) vector product $\left(\frac{1}{r^2}\right)\left(\frac{r}{r}\right)a_G(r)$, resulting in scalar field values.

Just for the record: a cross product (yielding a vector field). 1) is not commutative i.e. not suitable for acquiring validity at quantum-scale, and 2) would require a non-existing second component in gravity, e.g. curl for $\delta M(r)/\delta t = \nabla X$, i.e. X as 2nd component and 3) would yield the zero vector.

The dimensional interpretation of (2) is that $(1/r^2)$ physically relates to a spatial spherical expanding surface reducing the gravitational field density, which accounts for the field decay, and $\boldsymbol{r}/r = \boldsymbol{r}/|r|$ as unit vector determines direction of $a_G(r)$ i.e. in the opposite direction of r.

In the end-perhaps surprisingly-by the mathematics formally continued in vector space, the result is a scalar field derived from 2 vector fields, in contrast with an often-assumed vector acceleration or force field. Before moving on with the derivation, it is worth noting that equation (2) taken into vector space, in principle has similarity with the original summation description of gravity of Newton [12], at the time being considered not to be solvable under generic conditions and mass distributions; the validity of the equation is for $r > 0$, and the equation is exact (!) under fully symmetrical conditions. The value of the field as function of r is thus being provided by each pair of vectors of the two vector fields in making up the inner product of $\nabla.\Phi(r)$ and $\boldsymbol{r}/r$, then yielding a scalar field of field strength $a.(\boldsymbol{r}/r) = a \cos\pi = -a$, i.e. acceleration values in opposite direction of $\boldsymbol{r}$:

$$\nabla.\Phi(r) = -a_G(r) \tag{3}$$

$GM\left(\frac{r}{r}\right)\left(\frac{1}{r2}\right) = \left(\frac{GM}{r^2}\right)\left(\frac{r}{r}\right)$, i.e. with unity vector $\left|\frac{r}{r}\right| = 1$, the field magnitude value $a_G(r)$ is

$$a_G(r) = \frac{GM}{r^2} \tag{4}$$

Two conclusions can be drawn from equation (4):

1) Instead of a direct force, the acceleration field magnitude values $a_G(r)$ act as mediator of the force i.e. a deterministic scalar field of acceleration values expanding in space directly after creation of mass on quantum level. This scalar field is the result of two vector fields, for each spatial location delivering one pair of vectors $\nabla.\Phi(r)$ and unit vector $\boldsymbol{r}/r$, in the commutative vector inner product i.e. by the commutative property of this product, eq. (4) fully acquires validity in the descriptions at quantum Planck scale and therewith is mathematically consistent at all scales.

As argued, the temporary energy exchange i.e. both the interaction $(M \rightarrow m)$ of (external) mass m in the potential field of gravity of M and vice versa $(m \rightarrow M)$ relate to motion-changes of mass e.g. acceleration by 'give and take '(or 'take and give', depending which side you're on) energy exchange with the potential field, which can be accomplished by local bosons interacting with the field i.e. the action of acceleration value resulting in force on quantum scale is immediate.

The gravity field then emerges in space as a scalar field of acceleration field strength values GM/r^2 , and therefore the force F_G is a direct effect of cq. caused by coupled scalar bosons interacting with the field; the only scalar boson found to date (2023) is the Higgs' boson, and its quantum is postulated to be a scalar Higgs' -type boson. The field has the property of expanding in space directly at creation of the source, i.e. the acceleration values of the field emerge and are manifest as the magnitudes of the vector field i.e. $|a(r)|$ and therefore the conclusion arrived at is: the graviton i.e. quantum boson of the gravity scalar field is a mediating Higgs'(-type) scalar gauge boson, spin 0 - (deviating from the classical prediction of spin 2, result of the stress tensor). The gauge is a function of r and any measurement of the value (or force on mass at this position) in space yields the predetermined value, whichever mass (M, m) is applicable as source. This Higgs'-type boson then constitutes the graviton as mediating scalar gauge boson. The second conclusion is:

2) Equation (4) $a_G(r) = GM/r^2$ is the field description of a point source with mass M i.e. without dimension, and at first sight yields two singularities at $r = 0$. This is exactly where the dimensionless point source of gravity is defined; i.e. an example of variable validity violation (vvv), as the mathematics state $r > 0$, i.e. a priori excluding the location of the point source, in fact excluding a most interesting part: the source of gravity. This illustrates the importance of introduction of dimensions on the Planck scale by substitution of M by specific mass density M_s in a (e.g. spherical) volume. By a tighter definition in System Sources of the source dimension, singularities disappear i.e. they in fact in physical reality do not exist as validity is $r > 0$ in the straightforward mathematics of the point source. Abandoning the point source by introducing e.g. a spherical volume $V = 4/3\,\pi r^3$ $(r_{max} = R)$ and specific mass density M_s, the substitutions applied in (4) yield for the field strength

$$a_G(r) = \left(\frac{4\pi r^3}{3r^2}\right)GM_s = \left(\frac{4\pi r}{3}\right)GM_s \quad \text{for } (0 \leq r \leq R) \tag{5}$$

Valid for $r \geq 0$ inside the source with radius R and yields an expected acceleration $a_G(r) = 0$ by gravity of M at $r = 0$ in the center of M, increasing linear towards the surface at R of the core (see: point source), decaying for $r > R$ by GM/r^2, and thus in principle include the radius of curvature where photons cannot escape i.e. the Schwarzschild radius.

SYSTEM SOURCES – SINGULARITIES, NORMALIZATION

One of the sources below can be used, as a point-source is a mathematical abstraction causing anomalies.

Point source

In Gravitational Potential: At $r = 0$, the mathematics would be required to provide all values of the field strength between 0 and infinite, i.e. is undefined at the location of the source, therefore is excluded a priori by validity of variable r: $r > 0$. This can be solved in two ways, 1) by including room for the field change e.g. $0 < r < r_1$, evolving e.g. with $f(r) = Cr$ so that C is constant, treated in Schwarzschild Radius (14) and Gravitational Potential (5), by including a sphere around $r = 0$ with a mass density in the volume $4/3(\pi r^3)$, i.e. includes $r = 0$ in the variable validity: $r > 0$, or 2) by definition of the field value at $r = 0$ e.g. by a generalized Dirac function, the Dirac source.

Dirac Source

The Dirac source in system-theory is convenient as it describes the normalized field generation in terms of an ideal pulse (creation) of mass in the natural domain by the Dirac function: $\delta m(r,t) = 1$ at r, valid at $t_1 = 0$ (i.e. in the 'big bang'). In the transformed (k,r) frequency domain i.e. the curvature domain, the amplitude at all the frequencies i.e. of curvature yields '1' i.e. an equally ideal uniform distribution in the transformed domain. By considering a non-ideal source of e.g. a spherical volume around $r = 0$ instead of a Dirac function at $r = 0$, 1) room is created for the function and 2) it is possible to arrive at the non-ideal frequency distribution in terms of curvature in space (i.e. underlying the proposal in this paper).

Singularity

In case of the point source field, the singularities are vvv's and don't have a physical meaning, and as well can be removed by either one of the two proposed possibilities in System Sources, illustrated in the classical description in Schwarzschild Radius. This as well can be shown for e.g. the Kretschmann invariant [13], a description with 2nd derivatives of the Einstein tensor metric, where r^6 drops out from the denominator when substitution for M is applied as illustrated in System Sources-the singularities disappear. The foregoing as well shows that by expanding to a realistic source, the distribution in the transformed domain of the non-ideal i.e. a physical source, is 'shaped' i.e. shown as deviation from an ideal value '1' in the variable amplitude (intensity) in occurrence of curvature in space trajectories i.e. as direct result of mass distribution in space on quantum and classical level.

GEODESIC CURVATURE

Using the results in Gravitational Potential for quantum objects M and m in each other's field, the accelerations are in the field of m: $a_1(r) = Gm/r^2$ with force $F_1 = MGm/r^2$ and in the field of M: $a_2(r) = GM/r^2$ with $F_2 = mGM/r^2$. The total force F_G between objects then is

$$F_G = \frac{2GMm}{r^2} \tag{6}$$

Based on the conclusion of validity in Gravitational Potential eq. (4), upscaling (6) by $M \gg m$ to e.g. a black hole M, and by considering the principles of action and compensation, we explore the motion of m. For the motion in a field of M, without influences of other sources, the trajectory is to comply with the 'principle of least action', Lagrange [14], Feynman . The actions are two accelerations: of gravity and of curved motion, leading to gravity force F_G and in curved motion required centripetal force F_C i.e. F_G acts as the required F_C. With $F_G = F_C$ in the entire trajectory taken by the particle in the field, gravity force F_G delivers F_C, resulting in zero acceleration of the particle in the trajectory: the curved geodesic.

I.e. gravity acceleration a_G experienced by m is compensated in curved motion of m by the centripetal acceleration a_C on m, thereby yielding the 'least (stationary) action' in the movement of a particle in the field, where F_C is perpendicular to the tangent vector T of the curved trajectory. Note that in compensation, the actions of accelerations and forces are physically present. With $F_C = (mv^2)/r = kmv^2 = F_G$ we find

$$\frac{2GMm}{r^2} = \frac{mv^2}{r} \tag{7a}$$

This equation elegantly reveals where the twain almost secretively meet: mathematically at first sight mv^2/r violates the uncertainty relation in quantum perspective by simultaneous exact use of $p = mv$ and r. The RH part of equation (7a) however is in the transformed domain i.e. (k,r) space domain with $k = 1/r$ and r may be anywhere (x,y,z) i.e. undefined spatially on the surface of a sphere with radius r, i.e. indicating that in eq. (7a), variable r physically acquires a different meaning left (field decay) and right (curvature $1/r$). The resulting eqs. (7) and (8) therefore are valid in the quantum realm. Mathematically it takes the form as in eq. (8) with $k(r)$.

Schwarzschild was the first to publish [1] eq.(14) the exact solution and J. Droste in [2] put a footnote arriving at his eq. (7) , agreeing that it was equal to (14) in his 1916 paper.

In the derivation of J. Droste [2], his notion of different meaning of r is captured strikingly in his phrase "this r is not the same as occurs in (4)" after his substitution $\xi = a/r$, arriving at his eq. (7) in the original 1916 paper, allowing both field decay and curvature in his (and Schwarzschild's) results to be combined mathematically with different validity of variables r in 1 equation. Maintaining the separation of domains in (7a), by the curvature $k(r)$ and natural domain i.e. 'not the same r as in (4)', variables r left and r right remain separated.

$$\frac{2GMm}{r^2} = \frac{mv^2}{r} = kmv^2 \tag{7}$$

i.e. in a field of gravity source M, at distance r, the trajectory of particles is deformed with curvature $k(r)$ from straight:

$$k(r) = \frac{2GM}{r^2 v^2} \qquad (r > 0\ , v > 0 \text{ and } M > 0) \tag{8}$$

In (7), at first sight the mass of the test particle m drops out (instantly giving rise to interpretations), and as result in (8), the curvature of the geodesic trajectory at distance r of a black

hole with property M is governed only by the speed v and location r of the particle in the gravity field of M. Outside the field e.g. $r \to \infty, k = 0$, at large distance and/or very weak fields, in practice no curvature is present because of M.
Eq.(8) as well illustrates ad hoc the principle of multi-path summations of Feynman [15] by the resulting least-action trajectories of mass quantum particles in the field of M: the curvature at r depends on the speed v of the particles, and a myriad of trajectories thus exist for quanta which are 'least action' i.e. eq. (8) includes the set of trajectories escaping the source e.g. particles in the 'lensing' property of strong gravitation. In case of mass(ive) particles, (8) is rewritten with $E_{\mathrm{mk}} = ½\, mv^2$, and

$$k(r) = \frac{GMm}{½\, mv^2 r^2} = \frac{GMm}{E_{\mathrm{mk}} r^2} \tag{8a}$$

In case of a photon in the field of a large enough M e.g. the black hole, the minimum value of curvature is reached at $v = c$, and curvature (8) yields by substitutions $r = r_s$, $\frac{1}{r_s} = \kappa_s$ and $v = c$:

$$\kappa_s = \frac{1}{r_s} = \frac{c^2}{2GM} \tag{9}$$

i.e. the Schwarzschild curvature/radius. Then in case of r_s i.e. a massive dimensional source instead of a point source, validity of r is $r > r_s$. For treatment of singularities see Gravitational Potential, System Sorces and Black Hole Horizon. The obvious conclusion: eq.(9) is identical to eq. (11). The latter is derived from the classical Einstein tensor equations in general relativity of a symmetrical spherical core and shows definitely where 'the twain meet' i.e. merge seamlessly.

THE BLACK HOLE HORIZON, SINGULARITY

The classical description is given by the solution of the Einstein tensor equations related to gravity. The Schwarzschild radius is the characteristic for a black hole, and is unique in the sense that such massive object only has a horizon hiding anything captured behind it. The exact solution for the Schwarzschild radius r_s from the Einstein equations is [1],

$$r_s = \frac{2GM}{c^2} \tag{11}$$

in which G is the gravitational constant, M the mass of the black hole. The value r_s is the radius where the curvature caused by gravity prevents photons to escape the black hole and are captured. If the massive body constitutes of one type of particle to e.g describe a neutron star, rs is the maximum radius (i.e. minimum curvature) where neutrons cannot escape. The mass M is again substituted with $m_{sn}V$ and speed $c = v$, the equation then shows

$$r_s = \frac{2Gm_{sn}V}{v2} \qquad \text{for all} \qquad (r_s > 0) \tag{12}$$

In case the neutron star is an almost perfect symmetrical sphere, substitution of $V = \frac{4}{3}\pi r^3$ yields $r_s = \left(\frac{4}{3}\pi r^3\right)\left(\frac{2Gm_{sn}}{v^2}\right)$ or

$$\frac{r_s}{r} = r^2\left(\frac{2G\, m_{sn}}{v^2}\right)\left(\frac{4}{3}\pi\right) \qquad \text{for all} \quad (r \geq 0)$$

$$\kappa(r) = r^2\left(\frac{2G\, m_{sn}}{r_s\, v^2}\right)\left(\frac{4}{3}\pi\right) \tag{13}$$

with m_{sn}= neutron specific mass (kg/m^3), r the radius of the star and particle speed v(m/s). At $r = r_s$ these yields for curvature $\kappa_s = 1/r_s$

$$\kappa_s = r_s\left(\frac{2Gm_{sn}}{v^2}\right)\left(\frac{4}{3}\pi\right) \tag{14}$$

Eq. (14) shows that at $v = c$ (m/s), curvature reaches the smallest value i.e. for photons in the outer part of a massive black hole.
Starting from the Einstein results $(r_s > R)$, property M is substituted by specific (average) mass M_s and volume V and thus relates to the mass inside the physical structure. This volume V introduces by substitution in (12) the factor r^3.
The conclusion is that equation (13) for massive objects, shows that with $r \to 0$ i.e. in the center, curvature $\kappa(r) \to 0$ (supporting the validity conclusion 2. in (4) and System Sources). For a black hole or planet that does not constitute of one type of particle, an average density $m_{Sav} = average$ specific mass (kg/m^3) may be introduced e.g. in a spherical layered structure with each layer a different specific density, with the same perhaps surprising effect for a black hole, the conclusion is: The intriguing naked singularity in a black hole in the classical Einstein derived descriptions disappears by a change to mass density as a property, illustrating the impact of exclusion of dimensions e.g. in interpretations and all related literature. From the equation (13) the conclusion is that in case of limit $r \to 0$, the curvature disappears and a (virtual) trajectory is straight, i.e. in a black hole with a higher specific mass than a neutron star and a concentration of mass towards the center, the curvature caused by gravitation at $r = 0$ equals 0 as well, which leads to the conclusion that a naked singularity does not exist in the center, in contrast with current interpretations, proposed 'wormholes' and assumed 'warped space' in the center of black holes. From both the quantum scale and the classical derivation abstracted point source as well as reality sources, the solution of zero curvature and thus zero acceleration due to gravity at $r = 0$, no singularity can be assumed - which fits fully in what is to be expected from a symmetrical model of an extreme massive large object, as the attracting forces of gravity in the center are fully compensated by symmetry, however don't disappear: mass in the center is attracted from all sides equally (resulting in tremendous pressure, decaying towards the surface), therefore the curvature of the (virtual) geodesic drops from maximum at the physical surface towards zero curvature in the center of the object .

CONCLUSIONS

A. Einstein concluded that the presence of concentrated mass e.g. of massive objects (black holes, stars, planets etc.) caused 'space'-curvature i.e. deforming space and thereby trajectories. In the treatment in Geodesic Curvature, mass of the object under study of its curvature at first sight disappears in (7), and without a (test) mass property showing up in this equation, therefore support for a conclusion of space-curvature seems obvious. Because of assumed space deformation, therefore the thought of gravity not being a fundamental force may have settled. However, derived from fundamental potential theory mathematics of fields (e.g. as for the electrical field) and with validity on the Planck scale and upwards, eq. (8) illustrates that curvature is governed by object property speed v $(0 < v < c)$ and location r in a gravity field of M i.e. the geodesic trajectory is curved, however space properties i.e. described by dimensions and coordinate systems, are not deformed i.e. do not act as cause of curvature e.g. by being stretched, compressed i.e. or otherwise locally deformed. Without a causality relation with dimension and coordinates obviously space deformation is not supported when the curvature does not consist of coordinate variables (x, y, z) directly in a deviating dimensional relation.

Furthermore, the argument that test mass m disappears (7) and thus curvature /deformation does not depend on the mass of the object, is false, as m dropped out in (7) because of compensation of acceleration in the stationary action principle causing zero acceleration in the geodesics, whereby physical properties remain present (i.e. do not disappear or 'vanish' in contrast with some singularities), shifting the gravity related property of the test mass m to energy mediated by mass m of the particle i.e. by (8a). Factually the result is fully independent of dimensions, which leads to the conclusion: 'space' is not deformed due to presence of matter. The model of a rubber sheet with massive objects visualizing gravity by deformations of space, therefore in fact turns out to be a truly bad example. Matter may be considered a kind of aggregation state of energy ($E = mc^2$) e.g. 'condensed as mass' at still high energy levels during the 'big bang' forming massive elementary particles, as status quo result of (spontaneous) symmetry breaking in an environment of continually lower energy density levels in an expanding universe. When space is not deformed, and with a mathematically proper definition of 4D spacetime with time as 4th, truly orthogonal component (instead of parameter axis) in an identical relation with (as) the other 3 dimensions, it therefore is not very likely that time in that case would be affected in any way by matter, not being related to a true property of a particle or energy. Deformation is for geodesic trajectories by cause-and-effect relations between field and (elementary) particle; trajectories are straight without gravity, and inside a gravity field depend on particle properties – i.e. similar as in an electric potential field and particles with electrical charge. Consequently, photons of different wavelengths i.e. energy, by identical speed of c (m/s), are affected showing identical deformed trajectories at a distance r_1 from a massive object M, causing the lensing property of light. Therefore, light and e.g. radio signals of objects, can reveal these objects in projection, when behind stars and e.g. black holes.

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