# About the problem of the conceptual incompatibility of gravitation and quantum theory

## A geometry dominated approach

the mathematical description of gravitational waves and their fundamental relationship with the four-path-integral and the Einstein-Hilbert-action

scientific essay

by

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**Has anyone ever thought about, that the quantum-mechanical wave-function could not be fundamental, but a special case of a parent equation?**

## Energy of linear gravitational waves – a first hint

An accurate calculation of the energy-density of gravitational waves leads to

$$t_{\mu\nu} = \frac{c^4}{8\pi\gamma} * k_\mu * k_\nu * |F_{\mu\nu}| \qquad (1.1)$$

An Integration over the function leads to

$$E_\mu/_A = \frac{c^4}{8\pi\gamma} * k_\mu * |F_{\mu\nu}| \qquad (1.2)$$

Energy is proportional to wavenumber and to frequency of the wave-function. This results in an unexpected connection to quantum-mechanics, which is not considered so far!

The analogy between two seemingly completely disjointed theories becomes even clearer if the point-symmetrical Planck-surface is assumed to be the surface energy
passed through.

$$A = A_0 \times \pi = \pi \times \hbar \times \gamma / c^3 \qquad (1.3)$$

This results in the energy

$$E = \mathrm{h} * f * \frac{|F_{\mu\nu}|}{8\pi} \qquad (1.4)$$

Of all the natural constants, only the quantum of action remains.

Thus, the present derivation is the only one with which the energy-frequency-relation can be derived unambiguously and independently of the quantum-mechanics. The divergences (curvatures) of all other conservative fields lead to different charge- and current-densities and cannot be used to define an energy.

## Can one conclude something from this formal similarity?

a) Equation of gravitational-waves: linearization and calibration of the tensor-field-equation of GR and reference to a constant background-coordinate-system of the Minkowsky-type

→ Analogously, the wave-equation of quantum-mechanics could follow from a quantized tensor-field -equation by the same approach.

b) Correlation between the four-way-element $ds^2$ and the metric $g_{u,v}$ allows to justify the quantization of the gravitational waves in hindsight.

→ effective way through a curved space-time by integration of metric over a four-way as a parameter.

here: product of the energy-surface-density of a gravitational-wave and Planck-surface actually four-way integral over the metric

$$ds^2 = g_{u,v} * dx_u * dx_v = -1 * c^2 * dt^2 + 1 * dx^2 + 1 * dy^2 + 1 * dz^2 \quad (2.1)$$

with Planck-length L as the entry of a non-infinitesimal, but finite four-vector $L_u$

$$Ds^2 = g_{u,v} * L_u * L_v \quad (2.2)$$

## A first approximation and its interpretation - Can a source-field be omitted?

$$R_{\mu\nu} - \frac{1}{2} * g_{\mu\nu} * R = \frac{8\pi\gamma}{c^4} * T_{\mu\nu} \tag{3.1}$$

in a first approximation, Einstein's equation is the four-volume-density of a new tensor-field-equation. Interpret source-field differently:

$$R_{\mu\nu} - \frac{1}{2} * g_{\mu\nu} * R = \frac{8\pi\gamma}{c^3} * H_{\mu\nu} * \frac{1}{dx^4} \tag{3.2}$$

a) Energy-momentum-density-tensor becomes a tensor whose elements correspond to actions.
b) Elements as multiples of the action-quantum leads to:

$$R_{\mu\nu} - \frac{1}{2} * g_{\mu\nu} * R = \frac{8\pi\gamma}{c^3} * H_{\mu\nu} * \frac{1}{dx^4} \tag{3.3}$$

$$R_{\mu\nu} - \frac{1}{2} * g_{\mu\nu} * R = \frac{8\pi h\gamma}{c^3} * N_{\mu\nu} * \frac{1}{dx^4} \tag{3.4}$$

$$R_{\mu\nu} - \frac{1}{2} * g_{\mu\nu} * R = \frac{16\pi^2\hbar\gamma}{c^3} * N_{\mu\nu} * \frac{1}{dx^4} \tag{3.5}$$

$$R_{\mu\nu} - \frac{1}{2} * g_{\mu\nu} * R = 16\pi^2 * A_0 * N_{\mu\nu} * \frac{1}{dx^4} \tag{3.6}$$

Elements in this definition are pure numbers, in the sense of quantum-theory, quantum-numbers for the geometry of Riemann space.

→ before: Einstein-equation - geometry of space-time and source-term
→ now: pure geometry, which actions are proportional. What is source, what is field?

→ Transition to an eigenvalue equation?

→ How is Planck-length related to curvature?

## general quantization based on the Einstein-Hilbert-action

$$S = \frac{1}{2} * \frac{c^3}{8\pi\gamma} * \int \sqrt{-\det(g_{\mu\nu})} * R(g_{\mu\nu}) * dx^4 \tag{4.1}$$

$$S * \gamma / c^3 = \frac{1}{2} * \frac{1}{8\pi} * \int \sqrt{-\det(g_{\mu\nu})} * R(g_{\mu\nu}) * dx^4 \tag{4.2}$$

→ Unit: area, better: distance-square

$$K * N * \hbar * \gamma / c^3 = \frac{1}{2} * \frac{1}{8\pi} * \int \sqrt{-\det(g_{\mu\nu})} * R(g_{\mu\nu}) * dx^4 \tag{4.3}$$

→ K: Planck-length or reduced Planck-length and still lacks a pre-factor?

a) Function should reproduce GR at the core

b) Boson-exchange of two masses gives maximum as a limit for the application of quantum-field- theory

$$M_p^2 * c^4 = E_p^2 = \hbar * c^5 / \gamma \tag{5.1}$$

$$E_p^2 = (\hbar * \mathrm{k} * \mathrm{c})^2 = \hbar^2 * \frac{(2\pi)^2}{\lambda^2} * \mathrm{c}^2 = \hbar^2 * \frac{1}{\mathrm{L}^2} * \mathrm{c}^2 \tag{5.2}$$

$$\mathrm{L}^2 = \hbar * y / c^3 \tag{5.3}$$

K=1 .

preliminary correspondence-principle for the extension of GR:

$$\hbar \rightarrow 0 \tag{5.4}$$

→ N disappears when the scalar curvature disappears.

→ The structure of the Minkowski space-time may be quantized, but does not contribute to the action S.

→ Intrinsic curvature must be given.

→ calculated action ħ represents the increase of a path S by ds, at the moment the geometry deviates from the flat space-time (R>0).

→ The nature of the deviation then additionally depends on the nature of the marginal- and secondary conditions, but not its amount.

→ Sections of the extent of Planck-length initially as tangential-spaces

→ Metric locally about this constant and counterpart to local inertial systems

→ Difference-quotients instead of differential-quotients

→ Metric must be able to vary almost arbitrarily weak! The limiting quantity is the four-integral over the curvature.

→ new term, superior to the metric: deviation from a Minkowski metric is *geodetic disturbance* $\boldsymbol{S_p}$.

→ Integral about curvature is positive definite.

→ Minimum of action is zero

→ negative lengths not possible.

→ *geodesic disturbance* of the Minkowski space-time requires quantization also based on the Planck-length. Distance between two directly adjacent points is the Planck-length

→ Planck-length as entry of a four-vector

→ Curvature of a path and curvature of space-time determined by non-colinear vectors of finite length.

## The minimum geodesic disturbance as amplitude

Definition of a speed:

$$\frac{ds}{dt} = \frac{1*s_0}{n_t*t_0} = \frac{1*c*t_0}{n*t_0} = \frac{c}{n} \tag{6.1}$$

$$\beta = \frac{1}{n_t} \tag{6.2}$$

→ β, multiplied by the appropriate length of the eigen-time in the observer system, is just balanced

→ alternating functions with Planck-length as amplitude

→ Metric is second derivative!

→ Geodetic disturbance $\boldsymbol{S_p}$ as the amplitude of a wave-like geodesic, depending on the solution considered

→ new parent-function!

## Gravitational waves from a new perspective - elementary connection between energy and degrees of freedom

a) constraints:

→ Path integral over any symmetric metric function always the same geodetic disturbance $\mathbf{S_p}$

→ quantization rule 1 $S_p \sim \hbar$

→ constraint: Lengths can not be negative

b) scalar geodetic disturbance, new parent-function is initially also scalar.

$$S(t,z) = S_p * F(\vec{r},t) = S_p * e^{i(\omega*t-k*z)} \tag{7.1}$$

→ partial derivation, conceivable as field and as eigenvalue

$$E = \hbar * \omega \tag{7.2}$$

$$\vec{p} = \hbar * \vec{k} \tag{7.3}$$

with base

$$\overrightarrow{e_1} \times \overrightarrow{e_2} = \overrightarrow{e_3} \tag{7.4}$$

$$\overrightarrow{e_1} * \overrightarrow{e_2} = 0 \tag{7.5}$$

two oscillation-directions defined and different from each other

$$\vec{E} = S_1(t, z) = S_p * F(\vec{r}, t) * \overrightarrow{e_1} \tag{7.6}$$

$$\vec{B} = S_2(t, z) = S_p * F(\vec{r}, t) * \overrightarrow{e_2} \tag{7.7}$$

→ Coupled vector-fields

→ phase shifted for gravitational-waves.

→ Only fully writable in Tensor notation.

→ Metric: two independent amplitudes, degrees of freedom

→ now: only one amplitude $\boldsymbol{S_p}$, degrees of freedom different bases or phase shift

$$\begin{pmatrix} \vec{E} \\ \vec{B} \end{pmatrix} = S_{\mu\nu} = S_p * F(\vec{r}, t) * \begin{pmatrix} e_1 & 0 \\ 0 & e_2 \end{pmatrix} \tag{7.8}$$

→ here continue spin-2 behavior for gravitational-waves

$$S_{\mu\nu} = S_p * F(\vec{r}, t) * \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \tag{7.9}$$

c) Consider the derivations of the parent-function

→ first derivative proportional to energy and momentum

→ However, here are real geometric sizes. Eulerian form only spelling!

→ Eigenvalues only positive extremes of geometry

$$\dot{S}_{\mu\nu} = S_p * \omega * F(\vec{r}, t) * \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \tag{8.1}$$

$$S'_{\mu\nu} = \mathrm{S}_p * |\vec{\mathrm{k}}| * \mathrm{F}(\vec{\mathrm{r}}, \mathrm{t}) * \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \tag{8.2}$$

→ *Geodetic disturbance* corresponds directly to physical action:

$$H_{\mu\nu} = \hbar * \varphi_{\mu\nu} * \mathrm{F}(\vec{\mathrm{r}}, \mathrm{t}) = \hbar * \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} * \mathrm{e}^{\mathrm{i}(\omega * \mathrm{t} - \mathrm{k} * \mathrm{z})} \tag{8.3}$$

→ Derivation after time is energy-size

$$E_{\mu\nu} = \hbar * \omega * \varphi_{\mu\nu} * \mathrm{f}(\vec{\mathrm{r}}, \mathrm{t}) = \hbar * \omega * \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} * \mathrm{e}^{\mathrm{i}(\omega * \mathrm{t} - \mathrm{k} * \mathrm{z})} \tag{8.4}$$

→ Analogous to quantum-mechanics energy as eigenvalue

$$E_{\mu\nu} * g^{\mu\nu} = \mathrm{E}^{\mu}_{\nu} = \hbar * \omega * \varphi^{\mu}_{\nu} \tag{8.5}$$

→ scalar of energy

$$E = \pm\sqrt{\textstyle\sum_1^2 \mathrm{E}^{\mu}_{\nu}} = \pm\sqrt{E_1^2 + E_2^2} = \pm\, \hbar * \omega * \sqrt{1^2 + (-1)^2} \tag{8.6}$$

$$\pm E = \hbar * \omega * \sqrt{2} \text{ (8.7)} \tag{8.7}$$

→ Normalization of the wave-function for compensation of the degrees of freedom

$$S_{\mu\nu} = \mathrm{S}_p * \frac{1}{\sqrt{2}} * \varphi_{\mu\nu} * \mathrm{F}(\vec{\mathrm{r}}, \mathrm{t}) = \mathrm{S}_p * \frac{1}{\sqrt{2}} * \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} * \mathrm{e}^{\mathrm{i}(\omega * \mathrm{t} - \mathrm{k} * \mathrm{z})} \tag{8.8}$$

d) Considering a light-fast process without rest-mass

$$\pm E = \pm\hbar * |\vec{\mathrm{k}}| * \mathrm{c} = \pm p * c \tag{8.9}$$

→ Sign only corresponds to possible propagation-directions

e) *Geodetic disturbance* always the same amplitude of a wave-function

→ only wavelength determines metric disturbance

$$S_{\mu\nu} = \mathrm{S}_p * \frac{1}{\sqrt{2}} * \varphi_{\mu\nu} * \mathrm{F}(\vec{\mathrm{r}}, \mathrm{t}) = \mathrm{S}_p * \frac{1}{\sqrt{2}} * \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} * \mathrm{e}^{\mathrm{i}(\omega * \mathrm{t} - \mathrm{k} * \mathrm{z})} \qquad (9.1)$$

→ Metric over two-fold derivative according to propagation-direction

$$\frac{d^2}{dz^2} S_{\mu\nu} = h_{\mu\nu} = \mathrm{S}_p * \frac{1}{\sqrt{2}} * \varphi_{\mu\nu} * (-\mathrm{k})^2 * \mathrm{F}(\vec{\mathrm{r}}, \mathrm{t}) = \mathrm{h} * \frac{1}{\sqrt{2}} * \varphi_{\mu\nu} * \mathrm{e}^{\mathrm{i}(\omega * \mathrm{t} - \mathrm{k} * \mathrm{z})} \qquad (9.2)$$

→ Metric as local disturbance, only as function of time.

$$\frac{d^2}{c^2 * dt^2} S_{\mu\nu} = h_{\mu\nu} = \mathrm{S}_p * \frac{1}{\sqrt{2}} * \varphi_{\mu\nu} * \left(\frac{\omega}{\mathrm{c}}\right)^2 * \mathrm{F}(\vec{\mathrm{r}}, \mathrm{t}) = \mathrm{h} * \frac{1}{\sqrt{2}} * \varphi_{\mu\nu} * \mathrm{e}^{\mathrm{i}(\omega * \mathrm{t} - \mathrm{k} * \mathrm{z})} \qquad (9.3)$$

→ Context: metric field - ie space-time - is the coupling of local oscillations to waves

→ only states are transported: energy (!), metric, curvature ..

→ important aspect in comparison with nonlocal aspects of quantum mechanics

f) Maximum *scalar metric perturbation* at known wavelength

$$\widehat{h_{11}} = \widehat{h_{22}} = \mathrm{S}_p * \mathrm{k}^2 = \mathrm{L}_\mathrm{p}^2 * \left(\frac{2\pi}{\lambda}\right)^2 \qquad (9.4)$$

→ how big will $h_{\mu\nu}$ be?

$$g - h = 1 - \mathrm{S}_p * \mathrm{k}^2 = 1 - \mathrm{L}_\mathrm{p}^2 * \left(\frac{2\pi}{\lambda}\right)^2 \qquad (9.5)$$

→ when components of $g_{\mu\nu}$will be singular for an external observer?

$$\lambda = 2\pi * \mathrm{L}_\mathrm{p} \qquad (9.6)$$

→ Perturbation defines luminous geodesics when wavelength is identical to unreduced Planck-length ($\mathrm{L}_\mathrm{p}$ was reduced Compton-wavelength)

→ size of $h_{\mu\nu}$ with orders of magnitude of quantum-mechanical processes, example electron

$$\lambda_\mathrm{e} \approx 10^{-12}\mathrm{m} \qquad (9.7)$$

$$h = L_p^2 * \left(\frac{2\pi}{\lambda}\right)^2 \approx 10^{-70+1+24} \approx 10^{-45} \quad (9.8)$$

→ size of $h_{\mu\nu}$ at 10 TeV:

$$\lambda \ = {}^{h * c}/_{E} \approx 10^{-33+8+6}\mathrm{m} \approx 10^{-19}\mathrm{m} \quad (9.9)$$

$$h \approx 10^{-70+1+38} \approx 10^{-31} \quad (9.10)$$

→ size of $h_{\mu\nu}$ in spectral-range of measurable gravitational waves?

$$\lambda_{gw} \approx 10^4 \,..\, 10^{12} \mathrm{~m} \quad (9.11)$$

$$h_{measured} \approx 10^{-24} .. 10^{-18} \quad (9.12)$$

$$h(\lambda_{gw}) = 10^{-70+1-(4..12)} \approx 10^{-73} .. 10^{-81} \quad (9.13)$$

$$\overline{h_{measured}}/h(\overline{\lambda_{gw}}) \approx 10^{-21+75} \approx 10^{54} \quad (9.14)$$

→ Comparison can be understood as the search for the tensor boson, the graviton, but is not universally valid!

→ Measured amplitudes act like a flow of the order of $10^{54}$ gravitons

## New aspects for properties of space-time

→ Gravitational wave is dynamic and alternates between two extremes.

→ Wave-field as a dynamic superposition would correspond to eigenfunction of the extremal geometrical perturbations of space-time, if these are eigenvalues

→ where and when does a certain geometric structure of space-time will be realized?

→ direct relation to the probability-aspect of quantum-mechanics and statements like Einstein-Podolski-Rosen-paradox

→ The geodesic disturbance $\mathbf{S_p}$ is identical to an excited state of magnitude ħ.

→ Quantum-mechanics: excited states always tend to assume the smallest possible value in a system

## Space-time and harmonic oscillator

→ formal similarity of the energy-equation for gravitational-waves and the wave-function of quantum-mechanics

→ fundamental quantum properties of space-time

→ gravitational properties of the wave-function of quantum-mechanics

→ Energetically, both solutions are completely equivalent

→ Difference primarily *interpretation* of the *type* and *unit* of elongation.

→ Wave-equation of quantum-mechanics no real value

→ Only absolute square-measure is a probability-density

→ but: wave-equations for physical, far-reaching fields:

1) linear, homogeneous wave-equations have always symmetric elongations
2) wave of the field has no divergent property in the sense of a charge
3) for gravitational waves: the effective far-field in the spatiotemporal mean is zero
4) wave-function defines paths which are just changed by amounts of the Planck-length

5) In the range of elementary particles (>$10^{-19}$m) the associated gravitational disturbance must have dropped by many powers of ten. An effect cross-section must correlate with the Planck-area
6) if the wave-equation of quantum-mechanics is identical then vacuum-energy can not interact gravitationally in the long run.

7) quantum-mechanical wave-function must be neutral element between the states of matter and antimatter, analogous to electromagnetic wave for the states of electric charge
8) quantum-mechanical wave-function describes at first only the *mechanical* properties of elementary particles, now also *gravitation*.

→ gravitational waves are a consequence of the coupling of the metric properties of space-time

→ Local disturbances affect the environment and thus transfer energy

→ The delay between two points in space just corresponds to a phase-shift due to the finite speed of light.

→ Space-time represents a field with physical properties

a) In the conventional, continuous view, the energy transfer results

$$\vec{I} = |t_{\mu\nu}| * \vec{c} \tag{10.1}$$

with

$$t_{\mu\nu} = \frac{c^4}{8\pi\gamma} * k_\mu * k_\nu * (h_{11}^2 + h_{12}^2) \tag{10.2}$$

b) Taking into account the derived quantization of the geometry, however, the energy follows for a local oscillation, ie for the derivative with respect to time for a specific spatial coordinate

$$E = \hbar * \omega \tag{10.3}$$

The derivation according to the spatial coordinates also produces an impulse

$$\vec{p} = \hbar * \vec{\mathrm{k}} \tag{10.4}$$

→ Quantum-Mechanics: States of Particles

→ quantum-mechanical wave-function deterministic and causal

→ By contrast, particles appear random and in some ways seemingly instantaneous!

c) new view: geometry of space-time

→ quantized space-time field is practically infinite many local oscillators

→ Field, ie space-time, is a quasi-continuous tissue with causal development that can transport local properties

→ Conclusion: local oscillators are coupled together in fixed order.

→ Conclusion: locally defined energy E transmits through space at the speed of light

$$E = \vec{\mathrm{p}} * \vec{\mathrm{c}} \tag{10.5}$$

→ Guideline: Quantum-field of constant energy (same frequency everywhere)

→ Conclusion: all local oscillators execute the same fundamental oscillation

→ Conclusion: Impulse can be seen as an energy transport.

→ Regardless of location and time everywhere the same energy transport

$$\frac{dE}{dt} = 0 = \frac{d\vec{\mathrm{p}}}{dt} * \vec{\mathrm{c}} = \frac{d\vec{\mathrm{p}}}{dx} * \mathrm{c}^2 \tag{10.6}$$

## Interpretation of the wave-particle-dualism and the quantum-mechanical uncertainty-relation

a) The field - space-time - is everywhere.

b) Local oscillations of its structure carry energy.

c) The coupling of these oscillations requires an impulse expressible as energy transport.

d) all metric oscillations of constant frequency represent the same energy

Result for position-unsharpness:

→ Particle is not an independent entity in space-time, but a state.

→ A measurement or disturbance does not require transport of energy to a specific location. Certainly no instantaneous process of energy or impulse shifts in any way.

→ Energy in this context is basically a field-value and the particle-concept at first moment not applicable.

→ Wave-equation is also field, *"eigen-function"* of the *field-structure*

→ Particles are defined as *"eigen-structure"* (curvature, metric ...), thus coded in the field

→ Fields are not local but extensive structures

→ principle unsharpness completely explained by the geometry

e) So far only semi-classical argued, probability-aspect left out.

→ if momentum is represented by energy transport due to the coupling of local oscillators, then a particle of energy E must be represented by the local structure of space-time present at a given location $X_{\mu}$ at a given time T.

→ However, real oscillation passes through all states defined by the phase and the derivatives of the wave-function, also neutral and negative.

→ it lacks particle-aspect, expectation-state and probability

→ Space-time assumes different, nearly continuous states, not proportional to whole quanta of action everytime

→ If extrema are expectation-states and intermediate-values are superposition-states, the wave -function can also be represented fully quantum-mechanically as a probability-field.

d) Geometric view provides explanation why information about momentum can be lost

→ Disturbance of the wave-function means that the energy-transport is effectively interrupted at the point of measurement. The energy is absorbed or scattered by a second particle.

→ not explainable by this view: global decoherence!

→ classically expected: wave breaks down with maximum speed of light

→ But: It collapses everywhere at the same time

→ unexplainable by this view: which state actually occurs at the place of measurement?

→ Energy is the same everywhere

→ Phase-related state of the wave (metric ..) happens to assume only one eigen-state

→ even more problematic: entanglement. However: geometric view can be applied as far as before, since entangled particles are described by only one wave-function!

*But it must not be forgotten that the wave function for the development of space-time is only one possible solution of many. The metric can oscillate or follow completely different functions, depending on the considered constraints and symmetries!*

## The coupling constant of the gravitational interaction

Fundamentally derived maximum metric perturbation is in fact identical in magnitude to the coupling-constant of gravitation, which is defined in quantum-mechanics analogous to the interaction-strength of quantum-electrodynamics

$$\hat{h} = S_p * k^2 = \mathrm{L_p^2} * \left(\frac{2\pi}{\lambda}\right)^2 \qquad (11.1)$$

with

$$m = \frac{E}{c^2} = (\hbar * \mathrm{k})/c \qquad (11.2)$$

$$k = (\mathrm{m} * \mathrm{c})/\hbar \qquad (11.3)$$

leads to

$$\hat{h} = S_p * \left(\frac{m*c}{\hbar}\right)^2 = \frac{\hbar*\gamma*\mathrm{m}^2*\mathrm{c}^2}{c^3*\hbar^2} = \frac{\gamma*\mathrm{m}^2}{\hbar*\mathrm{c}} \qquad (11.4)$$

$$\hat{h} = \alpha(m) \qquad (11.5)$$

→ Interaction rate automatically limited when absolute maximum of metric disturbance limits over the fundamental quantization of space-time based on the Planck-length.

## Super-fine-structure of the linear spectrum

On the basis of natural numbers, a super-fine structure of the spectrum of the linear wave-function can be derived by way of example. This would in principle be a measurable quantity to falsify the theory in general and the sub-thesis on the fine-structure in particular.

Every transition between permissible fundamental-oscillations is likely to have only specific wavelengths or energies

if

$$E(n) = \hbar * \omega = \hbar * (2\pi/2\pi * \mathrm{T_p} * \mathrm{n}) \qquad (12.1)$$

If the smallest difference dn = 1, then there is an energy difference

$$E(n_2) - E(n_1) = \frac{\hbar * c}{L_p} * \left(\frac{1}{n_2} - \frac{1}{n_1}\right) = \frac{\hbar * c}{L_p} * \frac{1}{n_3} \qquad (12.2)$$

$$E(n_1 + 1) - E(n_1) = \frac{\hbar * c}{L_p} * \left(\frac{1}{n_1 + 1} - \frac{1}{n_1}\right) \qquad (12.3)$$

$$\varepsilon(n) = \frac{\hbar * c}{L_p} * \left(\frac{n - n - 1}{n * (n \quad + 1)}\right) \qquad (12.4)$$

$$\varepsilon(n) = \frac{\hbar * c}{L_p} * \left(\frac{-1}{n^2 + n}\right) \qquad (12.5)$$

Under specification of a measurable energy-difference, the required fundamental oscillation can be determined

$$n^2 + n = \frac{\hbar * c}{L_p} * \frac{1}{\varepsilon} \qquad (12.6)$$

$$\left(n \quad + \frac{1}{2}\right)^2 = \frac{\hbar * c}{L_p} * \frac{1}{\varepsilon} + \frac{1}{4} \qquad (12.7)$$

$$n = -\frac{1}{2} + \sqrt{\frac{\hbar * c}{L_p} * \frac{1}{\varepsilon} + \frac{1}{4}} \qquad (12.8)$$

Naturally, n becomes very large for energies that can be reached today, so that some constants become negligible.

$$n \approx \sqrt{\frac{\hbar * c}{L_p} * \frac{1}{\varepsilon}} \tag{12.9}$$

$$n \approx \sqrt{\frac{\hbar * c}{L_p * e_0} * \frac{1}{\varepsilon_{ev}}} \tag{12.10}$$

if

$$E_{ev}(n) = \frac{\hbar * c}{L_p * e_0} \sqrt{\frac{L_p * e_0}{\hbar * c} * \varepsilon_{ev}} \tag{12.11}$$

$$E_{ev}(n) = \sqrt{\frac{\hbar * c}{L_p * e_0} * \varepsilon_{ev}} \tag{12.12}$$

A transition of 1 μeV would then correctly close to the super-fine-structure if the ground-state is the magnitude reaches

$$E_{ev}(\varepsilon_{ev}) = \sqrt{12{,}209 * 10^{27} * 10^{-6}} eV \tag{12.13}$$

$$E_{ev}(\varepsilon_{ev}) = 11{,}04943 * 10^{10} eV \tag{12.14}$$

$$E_{ev}(\varepsilon_{ev}) = 110{,}4943\ GeV \tag{12.15}$$

The difference from the ground-state would be the relative

$$\varepsilon_{ev}/E_{ev}(\varepsilon_{ev}) = 1{,}7171 * 10^{-17} \tag{12.16}$$

Such a measurement seems almost hopeless, but would still be far easier than trying to directly reach the Planck-energy. After all, modern accelerator-systems reach energies in the range of a few TeV. The measured mass of the Higgs boson is even above this value.

## Can statements of known physicists be confirmed?

William Clifford (*On the Space-Theory of Matter,* Cambridge Philosophical Soc. (lecture on 21.2.1870)):

<< *The curvature of small areas of space continues like a wave. This change in the curvature of space is what we call the movement of matter.*>>

→ interpret more generally (space-time, not space alone!) and add quantization of action.

Albert Einstein:

<< *Can not we simply drop the concept of matter and develop a pure field-physics?*>>

→ probably yes! The moment in which the source (matter) is described, itself as the stimulus of space-time. Here GR is fundamentally retained. Why did Einstein not succeed? Involvement of quantization of action is missing.