

Selected „views of the world“ from physicists and philosophers regarding the proposed quantum gravity model

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„looking back, part (C)“ on a 10 year journey to ...

Schrödinger's and Schopenhauer's views on the world, (ScE1), (ZIR), were influenced by the East Asian philosophy. From (GyG) p. 113, p. 120 we quote

„All phenomena that appear to my mind are the nature of my mind. My mind is the nature of emptiness“

„Emptiness is the true nature of all (mind produced) phenomena (like clouds, mountains, planets, bodies, minds)“.

In (UnA1) the concept of „*Vision – Mathematization – Simplification*“ is proclaimed. The „*Vision*“ is about a quantum gravity model. The „*Simplification*“ is about a reduction of the number of „constants of Nature“, below the status from ~1930. The part B is basically about the „*Mathematization*“ of this concept (see also page 3 below). In a nutshell this is about (*)

1. acknowledge the primacy of a truly geometric Hilbert space model against the metric space model of the field continuum (as every Hilbert space is a (norm based) metric space, but not the other way around due to a missing *inner* product); the proposed Hilbert spaces are built by decompositions in the form $H_{-1/2} = L_2 \otimes L_2^{\perp}$, $H_{1/2} = H_1 \otimes H_1^{\perp}$, where by the (standard) Hilbert spaces L_2, H_1 of quantum theory are compactly embedded into the extended Hilbert space $H_{-1/2}, H_{1/2}$ to reflect the countability requirement of physical models
2. acknowledge the primacy of a (micro, $H_{-1/2}, H_{1/2}$) quantum world against the (macro, L_2, H_1 approximation only) cosmology world, (DeH), see also appendix Ad 6.
3. acknowledge the Mach principle as a selection principle to select the appropriate model out of the known physical relevant ones, (DeH)
4. acknowledge Lorentz' hypotheses (leading to Einstein's special relativity theory) and Einstein's lost key, „a variable speed of light“, (UnA), as constitutive principles for the macro world model; „*Nothing forces us to assume that ... clocks have to be seen as running at the same speed*“, A. Einstein
5. acknowledge the global nonlinear stability of the Minkowski space as a constitutive principle for the macro world model, (ChD)
6. acknowledge Bohm's property of a „particle“ for quantum fluctuation, (BoD), chapter 4, section 9, (SmL).

The proposed quantum gravity model reduces the zoo of elementary particles of the SMEP to only two quantum particles (which Plemelj called „mass element“) with or w/o existing (mathematically defined) classical density, while only the first one can be affected resp. allows the definition of kinematical notions in correspondingly defined variational L_2, H_1 based Partial Differential or Pseudo Differential Equation models.

In philosophy the baseline principle in idealism is a two-world theory. The two most prominent philosophers of the idealism are Plato and Kant: Plato distinguishes between the changing finite world of „perceptions“ and the eternal, not changing world of the „eternal forms“ (also named „ideas“), while Kant distinguishes between the world of „phenomena (appearances)“ and the inaccessible „Ding an sich“ (the thing-in-itself). The possibilities of awareness (recognition) are limited by certain pre-requisites, which Kant clusters in different categories. Schopenhauer used the notion „representation“ alternatively to „phenomenon“ and simplified Kant's table of categories (**). He as well acknowledge the two-world theory, but to enable conceptually the accessibility to the „world beyond“ he extendend the human „empirical consciousness“ to a human „better consciousness“, finally leading the concept of „will“ as a counterpart of „representation“. It is a kind of "vital principle" or "living energy" affecting both, dead matter and creatures. This can be interpreted as counterpart of the model components given by L_2^{\perp}, H_1^{\perp} affecting kinematical „elements“ in L_2, H_1 , while the borderline is governed by Nature constants.

(*) For some further details we refer to the appendix

(**) Schopenhauer used the notion „representation“ alternatively to „phenomenon“. His dissertation „*about the fourfold root of sufficient reason*“ is about a „*theory of explaining*“ based on four different kind of reasons assuming that „all what exists have a reason“, addressing the four reason categories causality, logic, space-time, acting, based on the assumption that "something is, because something else has been before". The related human „empirical consciousness“ answers the „why“ question in the world of phenomena. In later notes Schopenhauer proposed a „better consciousness“ as a counterpart of „empirical consciousness“ to enable a possibility to address the „what“ question, i.e. what is beyond the world of „phenomena“ from a theoretical, but also from a human acting perspective. His final answer to this „what“ question (as described in „the world as will and representation“, is the concept of „will“ as a counterpart of „representation“. It is a kind of "vital principle" or "living energy" affecting both, dead matter and creatures.

As a side note we mention, that Heidegger never completed his „being & time“ regarding the notion „time“; the only considered „being“ (related to Kant’s „Ding an sich“) is analyzed in the context of phenomenology and Husserl’s hermeneutic method, i.e. in the framework of the world of perceptions. In the context of the above it is very challenging to find any argument that consistently aligns „being“ and „time“ on the same conceptual level, as „time“ is an only „perception“ related concept.

Schopenhauer’s „better consciousness“ (going beyond space, time, causality, etc.) might be interpreted as the essential ingredient of Einstein’s definition of „cosmic religion“, as described in the section "religion and science" of the german version of (his) "my view of the world", (EiA4). There he distinguishes between the following three types of religion, (1) fear religion, (2) moral religion, and (3) cosmic religion. The common characteristic of the first two types is about the antropomorphic character of the idea of god. Regarding type 3, we quote from (EiA4), „Religion und Wissenschaft“:

„Das Individuum fühlt die Wichtigkeit menschlicher Wünsche und Ziele und die Erhabenheit und wunderbare Ordnung, welche sich in der Natur sowie in der Welt des Gedankens offenbart. Es empfindet das individuelle Dasein als eine Art Gefängnis und will die Gesamtheit des Seienden als ein Einheitliches und Sinnvolles erleben. Ansätze zur kosmischen Religiosität finden sich bereits auf früher Entwicklungsstufe, z. B. in manchen Psalmen Davids sowie bei einigen Propheten. Viel stärker ist die Komponente kosmischer Religiosität im Buddhismus, was uns besonders Schopenhauers wunderbare Schriften gelehrt haben. – Die religiösen Genies aller Zeiten waren durch diese kosmische Religiosität ausgezeichnet, die keine Dogmen und keinen Gott kennt, der nach dem Bild des Menschen gedacht wäre. Wie kann kosmische Religiosität von Mensch zu Mensch mitgeteilt werden, wenn sie doch zu keinem geformten Gottesbegriff und zu keiner Theologie führen kann? Es scheint mir, daß es die wichtigste Funktion der Kunst und der Wissenschaft ist, dies Gefühl unter den Empfänglichen zu erwecken und lebendig zu erhalten.“

Regarding Einstein’s view „about the methodology of theoretical physics“ we further quote:

"Nach unserer bisherigen Erfahrung sind wir nämlich zum Vertrauen berechtigt, daß die Natur die Realisierung des mathematisch denkbar Einfachsten ist. Durch rein mathematische Konstruktion vermögen wir nach meiner Überzeugung diejenigen Begriffe und diejenige gesetzliche Verknüpfung zwischen ihnen zu finden, die den Schlüssel für das Verstehen der Naturerscheinungen liefern. Die brauchbaren mathematischen Begriffe können durch Erfahrung wohl nahegelegt, aber keinesfalls aus ihr abgeleitet werden. Erfahrung bleibt natürlich das einzige Kriterium der Brauchbarkeit einer mathematischen Konstruktion für die Physik. Das eigentlich schöpferische Prinzip liegt aber in der Mathematik. In einem gewissen Sinn halte ich es also für wahr, daß dem reinen Denken das Erfassen des Wirklichen möglich sei, wie es die Alten geträumt haben.

.... daß all diese Bildungen und deren gesetzliche Verknüpfungen sich nach dem Prinzip des Aufsuchens der mathematisch einfachsten Begriffe und deren Verknüpfungen gewinnen lassen."

Regarding the topic of recognition and its related two illusions we refer to his article „Bertrand Russell und das philosophische Denken“ from which we quote:

„Wenn Berkeley darauf fußt, dass wir nicht „Dinge“ der Außenwelt durch unsere Sinne direkt erfassen, sondern daß nur mit der Anwesenheit der „Dinge“ kausal verknüpfte Vorgänge unsere Sinnesorgane erreichen, so ist dies eine Überlegung, die ihre Überzeugungskraft aus dem Vertrauen auf die physikalische Denkweise stützt.

Damit Denken nicht in „Metaphysik“ bzw. in leeres Gerede ausarte, ist nur notwendig, daß genügend viele Sätze des Begriffssystems mit Sinneserlebnissen hinreichend sicher verbunden seien und daß das Begriffssystem im Hinblick auf seine Aufgabe, das sinnlich Erlebte zu ordnen und übersehbar zu machen, möglichste Einheitlichkeit und Sparsamkeit zeige. Im übrigen aber ist das „System“ ein (logisch) freies Spiel mit Symbolen nach (logisch) willkürlich gegebenen Spielregeln. Dies alles gilt in gleicher Weise für das Denken des Alltags und für das mehr bewußt systematisch gestaltete Denken in den Wissenschaften.“

The considered decompositions $H_{-1/2} = L_2 \otimes L_2^1$ resp. $H_{1/2} = H_1 \otimes H_1^1$ are about the „coarse-grained“ (discrete spectrum/orthogonal eigenfunctions based) Hilbert space L_2 resp. H_1 , and closed sub-spaces L_2^1 resp. H_1^1 of $H_{-1/2}$ to overcome current gaps/weaknesses of the quantum theory and the gravity field theory.

Regarding the Maxwell equations there is a very first opportunity with respect to G. Mie’s consideration in 1912:

(WeH) p. 171: „On the basis of rather convincing general considerations, G. Mie pointed out a way of modifying the Maxwell equations in such a manner that they might possibly solve the problem of matter, by explaining why the field possesses a granular structure and why the knots of energy remain intact in spite of the back-and-forth flux of energy and momentum“.

The considered „decomposition“ distributional Hilbert space model addresses the main conceptual mathematical modelling caused weaknesses/gaps of (a) Dirac’s quantum theory of radiation (b) Einstein’s space-time geometry based field equations, and (c) a rather simple ODE model describing the expansion of the Universe governed by a expansion scale factor function $\alpha(t)$:

- (a) The main gap of Dirac’s quantum theory of radiation is the small term representing the coupling energy of the atom and the radiation field. (FeE): „Dirac’s theory of radiation is based on a very simple idea; instead of considering an atom and the radiation field with which it interacts as two distinct systems, he treats them as a single system whose energy is the sum of three terms: one representing the energy of the atom, a second representating the electromagnetic energy of the radiation field, and a small term representing the coupling energy of the atom and the radiation field“
- (b) The main gap of the Einstein field equations is, that it does not fulfill Leibniz’ requirement, that "there is no space, where no matter exists"; the GRT field equations provide also solutions for a vacuuum, i.e. the concept of "space-time" does not vanishes in a matter-free universe.
- (c) (MiZ): „The Friedman acceleration equation together with the fluid equation and the Friedman equation (which are all just Ordinary Differential Equations determines the expansion scale factor $\alpha(t)$ of the Universe. The nature of the solution strongly depends on the sign of the energy density term. In order to explain the expansion of the universe the cosmological constant is added (Einstein’s „grösste Eselei“). It is well known that there are significant discrepancies in the prediction of what order should be the value of the cosmological constant. The reason may lay in the course tuned asymptotic description of the scale of the acceleration factor $\alpha(t)$. The theory of regularly varying function provides the means for such an analysis, particularly for solutions of the the Friedmann (acceleration) equation. In (MiZ) it is shown under the assumption for the scale factor $\alpha(t)$, such as $\alpha(t) = t^\alpha$, solutions of the Friedman acceleration equation have a multiplicative term, which is a slowly varying function“.

ad (a)

(DiP1) „One of the most attractive ideas in the Lorentz model of the electron, the idea that all mass is of electromagnetic origin, appears at the present time to be wrong, for two separate reasons. First, the discovery of the neutron has provided us with a form of mass which it is very hard to believe could be of electromagnetic nature. Secondly, we have the theory of the positron a theory in agreement with experiment so far it is known – in which positive and negative values for the mass of an electron play symmetrical roles. This cannot be fitted in which the electromagnetic idea of mass, which insists on all mass being positive, even in abstract theory. ... We are faced with the difficulty that, if we accept Maxwell’s theory, the field in the immediate neighborhood of the electron has an infinite mass“.

ad (c)

(DiP) „The modern study of cosmology is dominated by Hubble’s observations of a shift to the red in the spectra of the spiral nebulae—the farthest parts of the universe—indicating that they are receding from us with velocities proportional to their distances from us. These observations show us, in the first place, that all the matter in a particular part of space has the same velocity (to a certain degree of accuracy) and suggest a model of the universe in which there is a natural velocity for the matter at any point, varying continuously from one point to a neighbouring point. Referred to a four-dimensional space-time picture, this natural velocity provides us with a preferred time-axis at each point, namely, the time-axis with respect to which the matter in the neighbourhood of the point is at rest. By measuring along this preferred time-axis we get an absolute measure of time, called the epoch. Such ideas of a preferred time-axis and absolute time depart very much from the principles of both special and general relativity and lead one to expect that relativity will play only a subsidiary role in the subject of cosmology. This first point of view, which differs markedly from that of the early workers in this field, has been much emphasized recently by Milne“.

(MiZ): „The ‘standard’ model of cosmology is founded on the basis that the expansion rate of the universe is accelerating at present — as was inferred originally from the Hubble diagram of Type Ia supernovae. There exists now a much bigger database of supernovae so we can perform rigorous statistical tests to check whether these ‘standardisable candles’ indeed indicate cosmic acceleration. Taking account of the empirical procedure by which corrections are made to their absolute magnitudes to allow for the varying shape of the light curve and extinction by dust, we find, rather surprisingly, that the data are still quite consistent with a constant rate of expansion“.

(C1) for some first touchpoints between philosophical "views of the world" and the proposed quantum gravity model we refer to the small books of the „views of (their) world“ from A. Einstein (EiA5) and E. Schrödinger (ScE1), as well as to Einstein's "ether and the theory of relativity", (EiA5) and Schrödinger's "statistical thermodynamics", (ScE) and "mind and matter" (ScE2).

From (ScE2) chapter 5, we quote:

„The great thing (of Kant's statement) was to form the idea that this one thing – mind or world – may well be capable of other forms of appearance that we cannot grasp and that do not imply the notions of space and time. This means an imposing liberation from our inveterate prejudice. There probably are other orders of appearance than the space-time-like. It was, so I believe, Schopenhauer who first read this from Kant“.

"To my view the 'statistical theory of time' has an even stronger bearing on the philosophy of time than the theory of relativity. The latter, however revolutionary, leaves untouched the unidirectional flow of time, which is presupposed, while the statistical theory constructs it from the order of the events. This means a liberation from the tyranny of old Chronos“.

The "time variable" can be introduced via the "action variable", defined as the solution of a corresponding ODE (HeW)

(C2) overall, it might be said, that while Schopenhauer's concept overcomes the "dialectic" concept of Fichte/Hegel (which is about the "practical ethics" dualism problem of the German idealism between "be" and "should be"), the proposed mathematical model overcomes the Copenhagen "dualism" interpretation (going back to Bohr/Born/Heisenberg) to "explain" the contractions between the apparently "parallel existing explanations" of wave (energy) and particle (matter) behaviors, which both have been verified experimentally by two different experiment

(C3) there is no longer an energy concept, which is somehow interwoven with concepts like forces, matter and causality, but which not includes the 99% "dark" energy / matter of the universe and its non zero vacuum energy. There is an extended energy concept proposed, which distinguishes between those two kinds of energy "classes" modelled as a decomposition of the Hilbert space $H_{1/2} = H_1 \otimes H_1^\perp$, while the (matter based) "bright" energy Hilbert (sub-) space H_1 is "only" compactly emdedded into $H_{1/2}$

(C4) Schopenhauer's and Schrödinger's views of the world were very much influenced from the Upanishades as presented in the Vedas. The above decomposition concept might be interpreted as analogy to the notion "Brahm", the universal, all flowing power, and the notion "Maya", the world of imaginations. In this case both notions become defined and part of a system with consistently defined related notions, i.e. they become part of the existing as a whole ("das Seiende im Ganzen"). In terms of Schopenhauer's conception of will & representation it corresponds to an aimless, cosmic, universal energy as the reason for the universe (will), and its appearance as representation. For Schrödinger's corresponding "view of the world" we refer to (ScE1) sections VI/VII, "An exoteric introduction to scientific thought" / "More about non-plurality"

(C5) regarding the perspectives of Schopenhauer's philosophy on phenomenology, existentialist philosophy and hermeneutics and the corresponding impact on scientific and metaphysical research we refer to (ReT).

(C6) for a quick overview with incredible insights to latest findings into a neuroscience view of the world and its relationship to chemistry (and therefore also to theoretical physics) we refer to (KIS).

(C7) for a direct relationship between Schopenhauer's concept of "will" and "the cosmic (or ontological) unconscious" of Zen Buddhism we refer to (FrE); from page 51 we quote:

„The will in its primary sense, as I said before, is more basic than the intellect because it is the principle that lies at the root of all existences and unites them all in the oneness of being. To be is to will and so is to become. There is absolutely nothing in this world that has not its will. The one great will from which all this wills, infinitely varried, flow is what I call the „Cosmic (or ontological) Unconscious,“, which is the zero-reservoir of infinite possibilities.“

(C8) as a kind of bridge to Buddhist philosophy between the personal dedication and some touchpoints to the above we would consider (KoJ).

With respect to Schrödinger's comment concering the liberation from the tyranny of old Chronos, the related "fermions Hilbert space based concept of "time" and "space", which can be introduced via the "action variable", we quote from (KoJ) p. 290:

"Last, we come to the innermost refuge. Here we take refuge in timeless consciousness and freedom. ... When we see with the eye of wisdom, we know that Buddha is timeless, unborn, unrelated to any body, any history, any place. Buddha is the ground of all being, the realization of the truth of the unmoving mind. This timeless Buddha is our true home, our abiding place. ... When we take refuge in the innermost dharma, we rest in the eternal freedom. ... When we take refuge in the innermost sangha, we acknowledge the inseparable connections of all our lives“.

Appendix

Ad 2.

From (UnA) chapter 8 we quote:

„The article (DeH) does no less than explain all known tests of the theory with variable speed of light“.

In the same article it is pointed out that the Mach principle is a cosmological principle, which, as there are multiple cosmological models, becomes also a selection principle to select out of the few existing physical relevant cosmological models. Therefore, in the sense of Kant, it is not a „constitutive“ principle (like the general co-variance of the Maxwell and the field equations and the Pauli exclusion principle), but a „regulative“ principle. In this sense the Mach principle is a principle for the very large (cosmology). In (DeH) it was also pointed out that the Planck action constant is independent from any weak or strong gravitation field. It somehow mirrors the fundamental difference of physical (approximation) macro and mathematical (c, governing) micro world. In this context we quote the very last two sentences in (DeH):

„The quantum theory gets primacy regarding the classical theory with its most perfect design, the general relativity theory. Therefore, the laws of the metric field, which are in principle independent from the laws of the quantum theory, have no absolute validity. The regularity of the metric field – indeed in a statistical way – would be tied with elementary particle interaction, like it is furthermore „located“ in the sense of the Mach principle.“

Schrödinger’s formula (ScE3) told us, that the negative potential of the total mass of the universe at a given point of observation (calculated with the valid gravitation constant G at this point) corresponds to half of the quadrate of the speed of light, $\frac{1}{2} \cdot c^2$. This approach of Schrödinger in (ScE3) was rediscovered by R. Dicke, (DiR), (UnA1); (we note that the momentum is given by $\frac{m}{2} \cdot v^2$) (*).

Lorentz’s interpretation of the Michelson-Morley experiment was, (SuL) 1.6:

„light speed is caused by the movements of bodies through the ether“.

Unzicker A., *„Vom Urknall zum Durchknall“* (english: Bankrupting Physics.), 2009: Dirac applied the special relativity theory to the Schrödinger equation leading to the attribute of „spin“ of an elementary particle. The ratio of the masses of a proton and an electron (about 1836,15 ...) are still w/o any model explanations. The Planck (action quantum) constant h corresponds approximately to $h \sim c \cdot m_p \cdot r_p$, where $r_p \sim 1,3 \cdot 10^{-15} m$. It leads Dirac to an estimate of the total number of elementary particles in the universe $\frac{M_{universe}}{m_{proton}} \sim 10^{80}$, (DiP).

(UnA), p. 78: „The principle of the constancy of the speed of light can be maintained only by restricting to space-time regions with a constant gravitational potential“, *Annalen der Physik* 38 (1912) p. 355-369;

(UnA) p. 121: „Einstein must also have assumed the coincidence $\frac{c^2}{G} \sim \frac{M_{universe}}{R_{universe}}$, i.e. $G \sim c^2 \frac{R_{universe}}{M_{universe}}$; this means that gravitation constant is related to the total mass of the universe, (which puts the spot on Mach’s principle), i.e. the gravitation constant is that small, because the total of the universe is that large (see also (BaJ), (ScD)); the formula $c^2/G \sim M_U/R_U$ allows an alternative interpretation of the observed deviation of the forecasted and measured speed of the Pioneer sondes (KrK), (SCL), (ToV); see also (UnA2).

The cosmology field equation model in (DeH) accompanied by properly defined domains enables weak variational representations in a Hilbert space framework. The calculus of variations is analogous to the elasticity theory regarding stress and strain tensors accompanied by the two Korn’s inequalities, (see e.g. (VeW)). According to the described meaning of the „Mach principle“ the corresponding physical meaning of the classical space-time continuum framework is „just“ a continuum approximation of the action of elementary particle interactions, (DeH). However, the weak variational representation of the considered extended Einstein SRT-Newton model enables a common modelling Hilbert space based framework with the quantum mechanics and Feynman’s related quantum electrodynamics.

(UnA2): *„Feynman’s theory worked so well that particle physicists decided to use it as a blue print for all other interactions“.* It results into a particle zoo, which is about 36 hadrons, 6 leptons and anti partners, W- and Z-particles and another series of colorful gluons. The extended framework $H_{-1/2} = L_2 \otimes L_2^1$ enables an „only“ two-type „elementary particle elements“ model, which is about Hilbert space elements with („fermions“) and w/o („bosons“) kinematical energy.

The in (DeH) proposed linearized (Lorentz-invariant) field equations contain the Newton/Poisson equation

$$\Delta \gamma_{44} = \left[\frac{8\pi G}{c^4} \right] \rho c^2.$$

Ad 4:

The role model from his experience is about the (simple) hypotheses as defined by H. A. Lorentz, from which he derived the special relativity theory. In the section "Address at the Grave of H. A. Lorentz" in (EiA4) he writes:

"from Lorentz' fundamental physical hypotheses (the electromotive field in a vacuum (ether) is generated by atomistic electrical charges, whereby the electromotive field is acting back to those charges in a counterproductive way) the special relativity theory was an immediate consequence".

We note that the same kind of quantum world hypotheses were used in (DeH) to argue, that the laws of the metric field are in principle independent from the laws of the quantum theory, not having absolute validity. The lawfulness of the metric field would be linked- indeed in a statistical way - to elementary interaction in the sense of Mach's constitutive (in the sense of Kant) principle. The related constitutive principle of the proposed quantum gravity theory is the Pauli exclusion principle.

(EiA3): „Nach dem soeben Gesagten müssen wir aber an Stellen verschiedenen Gravitationspotentials uns verschieden beschaffener Uhren zur Zeitmessung bedienen. Wir müssen zur Zeitmessung an einem Orte, der relativ zum Koordinatenursprung das Gravitationspotential φ besitzt, eine Uhr verwenden, die – an den Koordinatenursprung versetzt - $(1 + \frac{\varphi}{c^2})$ mal langsamer läuft als jene Uhr, mit welcher am Koordinatenursprung die Zeit gemessen wird. Nennen wir c_0 die Lichtgeschwindigkeit im Koordinatenursprung, so wird daher die Lichtgeschwindigkeit c in einem Orte vom Gravitationspotential φ durch die Beziehung $c = c_0(1 + \frac{\varphi}{c^2})$ gegeben sein. Das Prinzip von der Konstanz der Lichtgeschwindigkeit gilt nach dieser Theorie nicht in derjenigen Fassung, wie es der gewöhnlichen Relativitätstheorie zugrunde gelegt zu werden pflegt.“.

Ad 6.

(BoH), chapter 4, section 9:

„What we usually call „particle“ are relatively stable and conserved excitations on top of this vacuum. Such particles will be registered at the large-scale level, where all apparatus is sensitive only to those features of the field that will last a long time, but not to those features that fluctuate rapidly. Thus, the „vacuum“ will produce no visible effects at the large-scale level since its fields will cancel themselves out on the average, and space will be effectively „empty“ for every large-scale process (e.g. as a perfect crystal lattice is effectively „empty“ for an electron in the lowest band, even though the space is full of atoms)“.

(EiA) p. 52: „Die Gesetze aber, nach denen sich Ströme und Ladungen verhalten, sind uns nicht bekannt. Wir wissen wohl, dass die Elektrizitäten in Elementarkörperchen (Elektronen, positiven Kernen) bestehen, aber wir begreifen es nicht vom theoretischen Standpunkt aus. Wir kennen die energetischen Faktoren nicht, welche die Anordnung der Elektrizität in Körperchen von bestimmter Grösse und Ladung bewirken, und alle Versuche, die Theorie nach dieser Seite hin zu vervollständigen, sind bisher gescheitert. Wir kennen daher, falls wir überhaupt die Maxwell'schen Gleichungen zugrunde legen dürfen, den Energietensor für die elektromagnetischen Felder nur ausserhalb der Elementarteilchen. An diesen Stellen, den einzigen, wo wir einen vollständigen Ausdruck für den Energietensor aufgestellt zu haben glauben, gilt $\frac{\partial T_{ij}}{\partial x_j} = 0$ p.54: „wir wissen heute, dass die Materie aus elektrischen Elementarteilchen aufgebaut ist, sind aber nicht im Besitz der Feldgesetze, auf welchen die Konstitution jener Elementarteilchen beruht.“ ... p. 81. „Für ein Feldgesetz der Gravitation muss die Poissongleichung der Newtontheorie zum Muster dienen. ... Die Untersuchungen der speziellen Relativitätstheorie haben uns gezeigt, dass an die Stelle des Skalars der Massendichte der Tensor der Energiedichte zu treten hat. In diesem ist nicht nur der Tensor der Energie der ponderablen Materie, sondern auch der der elektromagnetischen Energie enthalten. Wir haben sogar gesehen, dass unter dem Gesichtspunkte einer tieferen Analyse der Energietensor der Materie nur ein vorläufiges, wenig tiefgreifendes Darstellungsmittel für die Materie anzusehen ist. In Wahrheit besteht ja die Materie aus elektrischen Elementarteilchen und ist selbst Teil, ja als der Hauptteil des elektromagnetischen Feldes anzusehen. Nur der Umstand, dass die wahren Gesetze des elektromagnetischen Feldes für sehr intensive Felder noch nicht hinreichend bekannt sind, zwingt uns vorläufig dazu, die wahre Struktur dieses Tensors bei der Darstellung der Theorie unbestimmt

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