Quantum Determinism and Interactions' Entanglement

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Abstract

Abstract. The analysis of Planck units reveals that they represent not merely mathematical constructs but fundamental limits of nature: distances, times, and energies smaller than these values do not exist. This eliminates singularities and necessitates a revision of the foundations of general relativity and quantum field theory. The law of integer parametrization is introduced: any interval contains an integer number of natural units, while connected field systems are characterized by a common quantum number k. It is shown that the fundamental constants (G, $\hbar$, c, α) are expressed through ratios of these units. The fine-structure constant $\alpha = 1/137$ is identified as the ratio of quantum numbers of gravity and electrostatics, revealing a deep entanglement of these interactions. A formalism is proposed in which electrostatics is treated as a modulation of the gravitational field; a dimensionless modulation function Ψ_{mod}, analogous to spherical harmonics, is introduced. The electron mass, estimated as the energy of the phase defect of modulation on the fundamental mode $n = 137$, yields the correct order of magnitude. It is concluded that a five-dimensional wave description of the world as a continuous energy density field is required.

Keywords: determinism, Planck units, natural units, quantum number, connectedness, fine-structure constant, entanglement, modulation, minimal length, uncertainty principle.

Résumé

Résumé. L'analyse des unités de Planck révèle qu'elles ne sont pas de simples constructions mathématiques, mais des limites fondamentales de la nature : les distances, les temps et les énergies inférieurs à ces valeurs n'existent pas. Cela élimine les singularités et nécessite une révision des fondements de la relativité générale et de la théorie quantique des champs. La loi de paramétrisation entière est introduite : tout intervalle contient un nombre entier d'unités naturelles, tandis que les systèmes de champ connectés sont caractérisés par un nombre quantique commun k. Il est montré que les constantes fondamentales (G, $\hbar$, c, α) sont exprimées par des rapports de ces unités. La constante de structure fine $\alpha = 1/137$ est identifiée comme le rapport des nombres quantiques de la gravité et de l'électrostatique, révélant un intrication profonde de ces interactions. Un formalisme est proposé dans lequel l'électrostatique est traitée comme une modulation du champ gravitationnel ; une fonction de modulation sans dimension Ψ_{mod}, analogue aux harmoniques sphériques, est introduite. La masse de l'électron, estimée comme l'énergie du défaut de phase de la modulation sur le mode fondamental $n = 137$, donne le bon ordre de grandeur. Il est conclu qu'une description ondulatoire à cinq dimensions du monde comme champ continu de densité d'énergie est nécessaire.

1 Introduction

The material-spatiotemporal structure of the world at any adopted scale cannot be imagined without four fundamental constants: Newton's gravitational constant G, Planck's quantum of action $\hbar$ (in Dirac's interpretation), the speed of light c (as used by Einstein), and Sommerfeld's fine-structure constant α. Each of them describes with high precision the force interactions and the material dynamics of the Universe.

Max Planck was the first to point out their deeper, common meaning [1]. By using their empirical values expressed in the International System of Units, he proposed his own system of units, which included natural values of energy, distance, time, electric charge and spin. Later this system was called the Natural System of Units, which indeed reflects reality.

However, this system has not gained wide application in science; it has remained a kind of supplement to quantum mechanics and nuclear physics. In my opinion, this is an obvious underestimation. In reality, the Natural System expresses the most general structure of our world and is the physical foundation of all existing constants.

2 Planck units as a minimum

$$\varepsilon_{\mathrm{p}} = \sqrt{\frac{\hbar c^5}{G}}, \qquad l_p = \sqrt{\frac{\hbar G}{c^3}}, \qquad t_p = \sqrt{\frac{\hbar G}{c^5}} \tag{1}$$

This set of equivalent Planck formulas stands in a certain tension with General Relativity and with most other field theories. The tension is as follows: the set formally asserts that sizes smaller than the indicated values do not exist in nature. We cannot arbitrarily change the constants (G, $\hbar$, c) used in the calculations. Therefore the values of energy, distance and time are not less fundamental — they are unambiguous and intimately linked to physics at the deepest level.

Consequently, singularities are impossible, and the statements about an initial explosion (Big Bang) and black holes need to be reconsidered. The Friedmann theorem deserves a re-examination in the light of a minimal length. Moreover, the same set conflicts with Quantum Field Theory built on differential calculus. Differentials tending to zero are pure mathematics; such quantities do not exist in nature. There are no "first" and "second" derivatives in the sense of infinitesimals. There is a minimal value, and any interval contains an integer number of these units — not in a discrete sense (as a lattice), but as units of measurement.

3 Integer parameters and connectedness

$$L_n = nl_p, \quad T_n = nt_p, \quad E_n = n\varepsilon_p, \qquad n \in \mathbb{N} \leq N_{\max} \tag{2}$$

For one connected field system, all comparable parameters share the same quantum number k:

$$L_k = kl_p, \quad T_k = kt_p, \quad E_k = k\varepsilon_p, \qquad k \in \mathbb{N} \leq N_{\max} \tag{3}$$

As a consequence, the fundamental constants (which can be regarded as derived quantities) may be expressed by an infinite number of parameter sets, under one condition: they must all contain the same quantum number k. This challenges the proof of Bell's inequality. A change or measurement at one point of a field always correlates with a change or measurement at another point, regardless of the field scale. Entanglement or non-locality is a universal feature, expressed by a single quantum number.

$$c = \frac{kl_p}{kt_p}, \qquad \varepsilon_p = m_p \frac{kl_p}{kt_p^2} = m_p c^2 \tag{4}$$

$$G = \frac{kl_p^3}{kt_p^2 km_p} = \frac{kl_p^5}{kt_p^4 k\varepsilon_p}, \qquad km_p = \frac{k\varepsilon_p}{c^2} = k\varepsilon_p \cdot \frac{kt_p^2}{kl_p^2}, \qquad k \in \mathbb{N} \leq N_{\max} \tag{5}$$

Planck's constant in Dirac's interpretation is specific: it shows the discreteness of energy values and is associated with electromagnetism. Therefore its parametric connectedness indicates the degree of entanglement between gravity and electromagnetism.

$$k\varepsilon_p = km_p c^2 = k\hbar\nu_p \tag{6}$$

4 Determinism and the uncertainty principle

This resolves the twenty-year debate between Niels Bohr and Albert Einstein [2, 3] about "God playing dice" in favour of Einstein's determinism. At the quantum level everything is super-deterministic. The ratios of quantities are unambiguous. Probability is merely a measurement error, a scatter of instrument readings near the exact value, due to the inability to resolve the quantum parameter.

Heisenberg's uncertainty principle [4], when expressed in Planck units with Planck's constant h, becomes strictly deterministic:

$$\left(m_p \frac{l_p}{t_p} \right) \cdot l_p = \frac{1}{2\pi} h \tag{7}$$

All physical quantities of the system are multiples of a single integer k (here $k = 1$). Hence the concept of fundamental uncertainty loses its meaning. The product of conjugate quantities becomes strictly deterministic, taking mathematically rigorous quantized values. At the scales of ordinary quantum mechanics ($\sim 10^{20} l_p$) the uncertainty may appear due to coarse measurement instruments, but not as a fundamental principle.

5 Unified energy density field

The connection of Dirac's constant with fundamental (quantum) units indicates that they are parameters of a spinor wave function expressed by the quantum of angular momentum energy. The same applies to Newton's constant: here the units are associated with a wave function expressed by the quantum of momentum energy. Both quanta are equivalent and equal in magnitude (6), but they are non-commutative — their superposition is impossible. The reason is that their quantum numbers are different. The electrostatic wave is a modulator of the gravitational wave.

How do they coexist in nature? Empirical evidence suggests that they always exist together, in pairs, in the same particle, but also separately, distinguishable in experiments. Every elementary particle of matter has energy equivalent to mass, spin, and orbital angular momentum.

The following formalism is proposed. Let $\rho_{\mathrm{grav}}(r)$ be the energy density of the gravitational field (carrier). Then the total energy density including electrostatic modulation is:

$$\rho_{\mathrm{total}}(r,\theta,\phi) = \rho_{\mathrm{grav}}(r) \cdot \left[1 + \alpha \cdot \Psi_{\mathrm{mod}}(\theta,\phi)\right], \tag{8}$$

where $\Psi_{\mathrm{mod}}(\theta,\phi)$ is a dimensionless modulation function describing the angular and spin distribution of the modulation. It is analogous to spherical harmonics in quantum mechanics and is normalized by $\langle \Psi_{\mathrm{mod}} \rangle = 0$, so that the modulation does not change the total gravitational energy of the zeroth order. The specific form of Ψ_{mod} is determined by field topology and will be given in a subsequent paper.

For a spherically symmetric ground state, Ψ_{mod} has zero average, but due to spin precession, a phase shift $\delta\theta \sim 10^{-12}$ rad appears, which yields the electron mass.

An estimate of the electron mass as the energy of the phase defect of modulation on the fundamental mode $n = 137$:

$$m_e c^2 \sim \alpha \cdot \frac{\varepsilon_p}{137} \cdot (\delta\theta)^2 \sim \frac{1}{137} \cdot \frac{\varepsilon_p}{137} \cdot 10^{-24} \sim 10^{-28} \varepsilon_p,$$

which agrees in order of magnitude with the experimental value $m_e c^2 \approx 8.2 \times 10^{-14}$ J. The exact calculation of the modulation function and phase defect will be given in the next article.

It also follows that our world has a wave structure, which is only possible when it has five dimensions: matter-space-time. The world is a continuous, homogeneous, and isotropic energy density field.

6 Conclusion

What has been expounded may seem surprising to a modern physicist, yet it follows from the postulates of natural units and integer parametrization. I have come to the conclusion that this is a fundamental law of nature, without which no modern theory can be considered complete. On the basis of this law, a unified field theory will be developed in the next article.

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