Quantum Determinacy and Connectedness of the World's Parameters

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Abstract

The material-spatiotemporal structure of the world at any adopted scale cannot be represented without four fundamental constants: Newton's gravitational constant, Planck's quantum of action in Dirac's interpretation, the speed of light as used by Einstein, and Sommerfeld's fine-structure constant. Max Planck first proposed a natural system of units based on these constants, expressing energy, distance, time, electric charge and spin. This system, however, has remained largely a supplement to quantum mechanics and nuclear physics. In this paper I argue that the natural system is deeply underestimated: it actually encodes the most general structure of our world and the physical foundation of all existing constants. The Planck set $\varepsilon_p = \sqrt{\hbar c^5/G}$, $l_p = \sqrt{\hbar G/c^3}$, $t_p = \sqrt{\hbar G/c^5}$ implies that no lengths smaller than these units exist in nature. Consequently, singularities are impossible, and the Big Bang initial singularity as well as black hole singularities are mathematical artifacts rather than physical realities. The Friedmann theorem requires reconsideration. Furthermore, standard quantum field theory based on differential calculus becomes problematic, because differentials tending to zero are pure mathematics — in nature there is a minimal value, and any interval contains an integer number of natural units. Thus $L_n = nl_p$, $T_n = nt_p$, $E_n = n\varepsilon_p$ with $n \in \mathbb{N}$. For one connected field system, all comparable parameters share the same quantum number k: $L_k = kl_p$, $T_k = kt_p$, $E_k = k\varepsilon_p$. As a consequence, fundamental constants can be expressed by infinitely many parameter sets, provided they all contain the same quantum number. This challenges the Bell inequality proof: a change or measurement at one point of the 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. The Dirac constant reveals the coherence of gravity and electromagnetism. The Einstein–Bohr debate about God playing dice is thus resolved in favour of Einstein's determinism: at the quantum level everything is super-deterministic; probability arises solely from measurement errors. Heisenberg's uncertainty principle, when expressed in Planck units, becomes strictly deterministic: $(m_p l_p/t_p) \cdot l_p = \frac{1}{2\pi}h$. These findings constitute a fundamental law of nature, without which no modern theory can be considered complete. On this basis a unified field theory will be developed in a subsequent paper.

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. 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 (the latter via Dirac's modified quantum of action). 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! Why? I shall try to explain.

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.

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.

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

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

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.

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

Determinism and the uncertainty principle

This resolves the twenty-year debate between Niels Bohr and Albert Einstein 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, 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.

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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