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Reciprocity Relation between the Mass Constituents of the Universe and Hardy's Quantum Entanglement Probability

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Abstract

In this short contribution, a reciprocity relation between mass constituents of the universe was explained governed by *Hardy*'s maximum entanglement probability of $\varphi^5 = 0.09017$. While well explainable through a set-theoretical argumentation, the relation may also be a consequence of a coupling factor attributed to the normed dimensions of the universe. Also, very simple expressions for the mass amounts were obtained, when replacing the *Golden Mean* φ by the *Archimedes*' constant π. A brief statement was devoted to the similarity between the *E-Infinity Theory* of *El Naschie* and the *Information Relativity Theory* of *Suleiman*. In addition, superconductivity was also linked with *Hardy*'s entanglement probability.

Keywords

Universe, Mass Constituents, Golden Mean, Archimedes' Constant, Reciprocity Relation, E-Infinity Theory, Information Relativity Theory, Entanglement, Superconductivity

1. Introduction

Since *Mermin* [1] recasted the results of *Hardy*'s *Gedankenexperiment* [2] of entangled states for two quantum particles with the maximum nonlocal effect in the form of a power of the Golden Mean $\varphi = \frac{1}{2}\left(\sqrt{5}-1\right)$ giving

$$P = \gamma_{\max} = \frac{1}{2}\left(5\sqrt{5}-11\right) = 5\varphi - 3 = \varphi^5 = 0.090169943\cdots, \quad (1)$$

this quantum entanglement probability P was shown by the outstanding Egyptian physicist *El Naschie* to describe the many puzzling features of our universe

very well such as dark energy, negative gravity or accelerated expansion of the universe [3].

In this short contribution, I want to complete a previous publication [4] and will describe the mass respectively energy constituents of our universe solely by *Hardy*'s probability of quantum entanglement of two quantum particles, pointing to an unexpected reciprocity relation between mass constituents of the universe.

Besides the *E*-infinity theory of *El Naschie* [5], the recently developed *Information Relativity Theory* (*IR*), created by *Suleiman* [6], should attract our attention, too. This theory offers a new physical interpretation of the dynamics of matter-wave duality confirming the *de Broglie-Bohm* interpretation of the Quantum Theory [7] [8] [9]. The chosen time respectively length transformations automatically involve the *Golden Mean*, which is the basic building unit of the *E*-infinity theory. According to the *IR* approach, the maximum kinetic energy density of a moving body at a recession velocity $\beta = v/c = \varphi$ is derived being φ^5 [6]

$$\frac{e_m}{e_o} = \frac{1-\beta}{1+\beta}\beta^2 = \frac{1-\varphi}{1+\varphi}\varphi^2 = \varphi^5, \text{using } \beta = \varphi \tag{2}$$

Indeed, this transformation equation for the kinetic energy density in terms of the recession velocity β resembles the maximum quantum entanglement probability P of two quantum particles given by *Hardy [2]* respectively *Mermin* [10]

$$P(2G, 2G) = \frac{1-x}{1+x}x^2 \quad [2]\ [10]. \tag{3}$$

Both mentioned theories (*E* respectively *IR*), if they can be brought into line, in the end, will have a lasting effect on our thinking and the perception of our existence.

2. Results

2.1. Reciprocity Relation and Hardy's Entanglement Probability

According to given results of the set-theoretical approach of *E*-infinity describing the five-dimensional *Kaluza-Klein* spacetime [4] [11], the amount of baryonic matter of the universe emerges as

$$\Omega_b = \frac{1}{2}\varphi^5 = 0.04508\ldots \quad \text{(about 4.51\%)}. \tag{4}$$

The dark matter amount can be recast in the very simple form of

$$\Omega_d = \frac{1}{100}2\varphi^{-5} = 0.22180\ldots \quad \text{(about 22.18\%)}. \tag{5}$$

It may not be pure fortuity but nevertheless surprising that both amounts show a reciprocity relation. This can be seen, if we write down the remaining dark energy amount as the difference to the entire mass in a more persuasive form

$$\Omega_{\Lambda} = 1 - \frac{1}{10}\left(5\varphi^5 + \left(5\varphi^5\right)^{-1}\right) \text{ (about 73.31\%).} \tag{6}$$

Such coincidence means that both mass constituents should not be considered independent of each other. Mathematically, reciprocity is found, for instance, if one considers volume in comparison to surface, or particles in comparison to waves. Relevant topological arguments from the set theory are summarized by *El Naschie* [11]. However, the denominator factor of 100 in Equation (5) may be interpreted as a coupling term equal to the normed dimensions of the universe [12].

The entire dark constituents yields

$$\Omega_{d+\Lambda} = \frac{5}{2}\varphi^2 = 0.954915\ldots \tag{7}$$

By the way, the simple result of $5\varphi^2$ represents the five-dimensional surface of the pre-quantum wave being the cobordism of the topological volume of φ^5 of the Kaluza-Klein five-dimensional manifold [4] [13] [14].

The estimated constituents are fairly well consistent with measurements of the *Wilkinson Microwave Anisotropy Probe* mission (*WMAP*) [15].

El Naschie recently pointed out that $D = \varphi^{-5} = 11 + 0.0901699\ldots$ obviously represents the fractal dimension D_M of *Witten's M*-theory [16] [17].

Because $\varphi^{-5} = 11 + \varphi^5$, its beautiful hierarchical form (or continued fraction representation) can be expressed as

$$\varphi^{-5} = 11 + \cfrac{1}{11 + \cfrac{1}{11 + \cfrac{1}{11 + \ldots.}}} = 11 + 0.0901699\ldots,$$

in contrast to the most unique representation for the *Golden mean*

$$\varphi = \frac{\sqrt{5}-1}{2} = \cfrac{1}{1 + \cfrac{1}{1 + \cfrac{1}{1 + \ldots.}}} = 0.618033989\ldots$$

2.2. Alternative Approach Using Archimedes' Constant π

An alternative approach for the mass constituents of the universe by applying the *Archimedes*' constant π instead of φ yields almost equal amounts in comparison to results according to Equations (4) to (7) [18] [19]

$$\Omega_b = \frac{\pi - 3}{\pi} = 0.0450703\ldots, \tag{8}$$

$$\Omega_d = \frac{\pi}{(\pi - 3)100} = 0.221875\ldots, \tag{9}$$

$$\Omega_{\Lambda} = 1 - \frac{1}{10}\left(\frac{10(\pi - 3)}{\pi} + \frac{\pi}{10(\pi - 3)}\right) = 0.733054\ldots, \tag{10}$$

and finally

$$\Omega_{d+\Lambda} = \frac{3}{\pi} = 0.9549296\ldots \tag{11}$$

for the sum of the dark constituents (matter and energy). It may turn out in the future whether this replacement may be of any physical importance. However, some numerical approximations connect *Hardy*'s entanglement probability φ^5 with *Archimedes*' constant π and the inverse of *Sommerfeld*'s fine structure constant $\bar{\alpha}_0$, respectively [20]

$$\pi - 3 \approx \frac{16}{137-24} = 0.14159292 \tag{12}$$

$$\bar{\alpha}_0 \approx 137 + \frac{2}{5}\varphi^5 = 137.03606\ldots \tag{13}$$

2.3. Hardy's Entanglement Probability and Superconductivity

If one deals with particle entanglement, superconductivity represents a physical phenomenon suspecting such property. Some years ago, the present author suggested linking the optimum hole doping σ_o of high-T_c superconductors with *Hardy*'s φ^5 entanglement probability [18]. The fractal-hierarchical structure of electrons entangled in pairs obviously determines this optimum near a quantum critical point that can be linked on the one hand with the universal fractal constant δ_1 = 8.7210972 … of the renormalized quadratic *Hénon* map (remember the quadrilateral layer structure of the cuprates)

$$\sigma_o \approx \frac{2}{\delta_1} = 0.2293, \tag{14}$$

on the other hand with *Hardy*'s entanglement probability

$$\sigma_o \approx \frac{8}{\pi}\varphi^5 = 0.2296, \tag{15}$$

this time connecting φ and π, the most important universal numbers of the cosmos.

The quotient of the *Fermi* speed to the *Klitzing* speed would yield

$$v_F / v_K \approx \frac{2}{\pi}\varphi^5 = 0.0571, \tag{16}$$

which is again proportional to φ^5 [20].

The fractal nature of electronic response in superconductors was documented some years ago by scanning tunneling microscopy [21] [22] and is consistent with generated *d*-wave fractal patterns in superconductors as a consequence of antiferromagnetism [23].

3. Conclusion

This contribution points to a reciprocity relation between the mass constituents of the universe that suggests their common physical interrelation. The obtained baryonic respectively dark mass amounts are related to *Hardy*'s maximum par-

ticle entanglement probability, namely the fifth power of the Golden Mean. Importantly, it is recommended once more to replace the *Golden Mean* φ in the mass relations by the *Archimedes*' constant π to utilize very simple expressions that await further interpretation. The competition between the two numbers obviously determines what the realities of our universe are. However, a *Nature* article just published reporting on a galaxy lacking dark matter halo is reason enough to re-evaluate the statements given here [24]. The opportunity opens to do an acid test with *Suleiman*'s theory [6]. The author's real interest in the cosmological relations including entanglement considerations is to catch an idea about the possible dark side of superconductivity.

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