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The Computing Quantum Universe and Einstein-Landauer's Principle of Mass-Energy-Information Equivalence

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Abstract

The proposed paper advocates the formulated Einstein-Landauer's mass-energy-information equivalence principle against criticism, provides evidence for its consistency with Standard Model theory, and formulates the concept of the self-computing Universe by natural kinds.

Keywords: Einstein-Landauer's mass-energy-information equivalence principle, Infogravity theory, Information Dualism Principle, Information by natural kinds, the self-computing Universe.

1 Introduction

The *Informational Gravity Theory* or *Infogravity Theory*, proposed in [5],[6],[7] resides on three main formulated hypotheses – the Self-Computational Evolutionary Fractal Universe Hypothesis [5], The Dualism of Information by Natural Kinds in the Evolving Universe Hypothesis [6], and the Universe's Evolutionary Information (*Plirophoria*) as Emergent Quantum Gravity and Fabric of Space-Time Hypothesis [7]. In their turn, each of these three hypotheses grounds on three well-known scientific principles –Einstein's mass-energy equivalence principle [1], Landauer's principle of thermodynamics of erasing of one bit of information [2,3], and Cramer's transactional interpretation of Quantum Mechanics [4].

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In the proposed paper, Einstein-Landauer's mass-energy-information equivalence principle is formulated as a consequence of the reunion of both Einstein's mass-energy equivalence principle [1] and Landauer's energy limit of erasing of one bit of information [2]. The account of Information by Natural Kinds for self-computing Universe as a Quantum Computer is formulated. Additionally, it is demonstrated that the claim in [9] suggesting that information lacks mass during computation by natural kinds contradicts the Standard Model.

2 Landauer's Principle for the Universe's Information by Natural Kinds

In [2], Rolf Landauer deduced the formula

$$E = Kb \times T \times \ln 2, \tag{1}$$

as the minimum cost of energy to erase one bit of information for irreversible calculations. As this principle was formulated for classical physics, to use it for quantum mechanics physics, one can use the mass-energy equivalence principle formulated by A. Einstein [1], $E = M \times c^2$ or $M = E/c^2$, to reformulate the Landauer's principle for mass as

$$M = Kb \times T \times \ln 2/c^2, \tag{2}$$

where Kb stands for Boltzmann's constant, T – for environmental temperature, $\ln 2$ for logarithm, and c – for speed of light. From the above, we can name the formula (2) as the ***Einstein – Landauer mass-energy-information equivalence principle***. That principle has at its core Einstein's mass-energy equivalence principle that, in its turn, works undoubtedly for most proven theories in physics – Einstein's relativity and Quantum Mechanics. Nevertheless, the possibility that it works also for the interpretation of the physicality of information casts doubts in the scientific community, for example, by M. Burgin [9]. They conclude that proponents of the physical nature of information, such

as R. Landauer [3], mistakenly confuse information with its physical carrier.

The account of information proposed in Infogravity theory is based on the philosophical concept of natural kinds. ***Information by natural kinds*** represents the flux of information at all instances of changes in the evolving fractal Universe from the quantum scale up to the Universe's scale. The Infogravity's theory framework excludes the anthropic principle that dominates some parts of existing scientific paradigm by postulating that the evolving computing Universe creates and stores at each instance only the information by natural kinds, without any "observer" interference in creating information.

As examples of information by natural kinds, one can take any chemical reactions that take place in living cells or Earth's oceans as primordial soup, in nucleosynthesis reactions in stars or colliding stars. All these changes by natural kinds represent small steps on all scales of the evolving Universe that finally caused the evolution of the Sun's planetary system and the evolution of the phenomenon of life on Earth. All these changes by natural kinds occur due to respective quantum effects that take place in respective reactants – as a superposition of electrons in valence bonds in atoms or tunneling of protons into an atom's nuclei. After these reactions occur, the new products replace the original reactants, as in fusion reaction, where helium replaces two hydrogen atoms. According to the hypothesis that the Universe functions as a self-calculating, evolutionary quantum computer, the loss of information from the two hydrogen atoms that no longer exist represents a classical erasure of information during irreversible calculations. For that specific case, Landauer's principle (1) has to be applied. However, why and how do we have to apply ***Einstein-Landauer's mass-energy-information equivalence principle*** (2) and use mass instead of energy in (1) for irreversible calculations by natural kinds? The following evidence will help us to answer the "why" half of that question, whereas the "how" half of the answer arises from the Principle of Information Dualism, formulated in [6, 7].

In [8], it is calculated that the "Total mass of hydrogen atoms used

per second to feed the Sun's core fusion reactions equals 650000000000 kg/s. The mass of one hydrogen atom equals 1.673×10^{-27} kg. Following that total ...1.08×10^{39} of single tunneling quantum effects per second...". In other words, within the Sun's calculating core, the amount of 1.08×10^{39} of information by natural kinds erasing effects occurs within the surrounding temperature of $T = 15000000$ K, or 1.5×10^{7} K. Following the logic of M. Burgin from [9], we have to count only on the Landauer's principle (1), not on the Einstein-Landauer's principle (2). If we do so, let us calculate the amount of additional energy **E(add)** per second. We will get from such an enormous amount of irreversible calculation per second as 1.08×10^{39}. To calculate this additional amount of energy per second, we use formula (1), where ***Kb*** is Boltzmann's constant, and find that

$$E(add) = 1.55 \times 10^{23} \text{ Joule/Second.} \tag{3}$$

It is well known as the scientific fact based on the Standard Model that the Sun's core produces per second the amount of energy as

$$E(Sun) = 3.8 \times 10^{26} J/S. \tag{4}$$

Under the Infogravity hypothesis that the Universe self-computes as a universal quantum computer, we cannot admit that the Standard Model is wrong if we follow the logic suggested by M. Burgin [9]. The only conclusion that can be drawn from this is that in a self-calculating Universe, the erasure of each qudit of quantum information follows the Einstein-Landauer's mass-energy-information equivalence principle (2). Therefore, each act of erasing quantum information results in the production of physical mass, as described in (2).

From Einstein-Landauer's mass-energy-information equivalence principle, it follows that per each change of one qudit of quantum information in the self-computing Universe, the amount of generated mass is

$$M = Kb \times T \times \ln 2/C^2 \text{ per unit of change as in (2),}$$

where Kb stands for Boltzmann's constant (5), T – for environmental temperature, $\ln 2$ – for logarithm, and $C = 3.0 \times 10^8 M/S$ – for speed of light.

For this purpose, we will use Boltzmann's constant in the following manner:

$$Kb = 1.38 \times 10^{-23} m^2 \times kg \times c^{-2} \times K^{-1}. \tag{5}$$

In the following, we will calculate the amount of produced mass for three instances of self-computing Universe. Firstly, $M(s)$ for a star's core with $T = 1.5 \times 10^7$ K, as there are as many as 2×10^{11} (two hundred billion) only in our galaxy, secondly $M(p)$ for Earth-like planets with $T = 2.88 \times 10^2$ K, and thirdly, $M(o)$ for outer space with only $T = 2.7$ K.

$$M(s) = 1.59 \times 10^{-33} Kg; \tag{6}$$

$$M(p) = 3.06 \times 10^{-38} Kg; \tag{7}$$

$$M(o) = 2.87 \times 10^{-40} Kg. \tag{8}$$

3 Conclusion

This paper produces evidence, consistent with the Standard Model, that for computations by natural kinds, the new mass (2) is generated at each step of the self-computing Universe according to Einstein-Landauer's principle. The Infogravity theory is formulated under the main assumption that the evolution of the Universe represents the self-computing process of the Universe as the Universal Quantum Computer. D. Deutsch formulated the possibility of the existence of such a Universal Quantum Computer [10]. Its possible architecture was formulated in [6]. The Information Dualism Principle of Infogravity theory, formulated in [7] and based on Einstein-Landauer's principle (2), explains that information by natural kinds persists in the Universe as embedded information in baryonic matter of the Universe from one

side, and as evolutionary quantum information of all quantum states of the matter in the Universe that precede the given ones, from the other side. According to the Infogravity theory, all the evolutionary information computed by the Universe as a Quantum Computer is topologically encoded in the generated mass (2) at each instance at all scales. The quantity of generated mass that encodes the evolutionary information is calculated for three main realms, as in (6), (7), and (8).

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