American Journal of Modern Physics
2013; 2(6): 357-361
Published online December 10, 2013 (http://www.sciencepublishinggroup.com/j/ajmp)
doi: 10.11648/j.ajmp.20130206.23

Experimentally based theoretical arguments that Unruh's temperature, Hawking's vacuum fluctuation and Rindler's wedge are physically real

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To cite this article:
Mohamed S. El Naschie. Experimentally Based Theoretical Arguments that Unruh's Temperature, Hawking's Vacuum Fluctuation and Rindler's Wedge Are Physically Real. *American Journal of Modern Physics.* Vol. 2, No. 6, 2013, pp. 357-361.
doi: 10.11648/j.ajmp.20130206.23

Abstract: The objective of the present paper is to argue that based on the reality of the observed increased rate of cosmic expansion, Unruh's temperature, Hawking's negative vacuum energy and Rindler's wedge must also be a physical reality. We present first a brief derivation of the missing dark energy density of the universe which is in absolute agreement with the most recent accurate cosmological measurements and observations. The derivation is based upon a Rindler space setting, the associated wedge horizon and Unruh temperature. That way the topological ordinary energy is found to be half of the topological Unruh fluctuation mass $m(O) = \phi^3$ multiplied with the square of the topological speed of light $c^2 = \phi^2$ where $\phi = 2/(\sqrt{5}+1)$. This is exactly equal to the area of the spear-like hyperbolic triangular part of the Rindler wedge. The corresponding physical ordinary energy density is thus $E(O) = \left(\frac{1}{2}\right)(\phi^3)(\phi^2)\, mc^2 = (\phi^5/2)(mc^2)$, where ϕ^5 is Hardy's probability of quantum entanglement. The topological dark energy density on the other hand is equal half of the topological Kaluza-Klein five dimensional mass $m(D) = 5$ multiplied with $c^2 = \phi^2$. This in turn is exactly equal to the circular segment part of the wedge which together with the hyperbolic triangular entangled area forms the complete Lorentzian invariant triangular area of the wedge. Consequently the physical dark energy density which is uncorrelated, i.e. disentangled is given by $E(D) = \left(\frac{1}{2}\right)(5)(\phi^2)(mc^2) = (5\phi^2/2)(mc^2)$ in full agreement with observation. Adding E(O) and E(D) one finds $E(\text{Einstein}) = mc^2$ in full agreement with all our previous derivations. From the above we argue that since measurements, observations and theory have shown the increased expansion to be real and because the present derivation of the same results is based on Rindler's space and Unruh's temperature, it follows as a logical necessity that Unruh's temperature, Hawking's fluctuation and Rindler's wedge are all physically real and can be measured, at least in principle.

Keywords: Hawking Vacuum Fluctuation, Unruh Temperature, Rindler Wedge, Dark Energy, Quantum Gravity, Cantorian Spacetime, Hyperbolic Fractal Geometry

1. Introduction

In previous work [1] two quantum relativity energy-mass equations were derived for the measured ordinary energy E(O) and its complimentary missing dark energy E(D) of the cosmos [2-9]. The results for energy densities so obtained were found to be in astounding agreement with accurate cosmic data and most recent cosmic observations [10-15]. In the present very concise and short paper we re-derive these two new fundamental equations generalizing Einstein's $E = mc^2$ [10-15] using a completely different concept based entirely upon Rindler's spacetime [16-18]. This is a boost-invariant two dimensional flat spacetime. In such space, a uniformly accelerated particle, which in a classical relativity setting undergoes hyperbolic dynamics, can be made to appear at rest [17]. We may recall that in a particular earlier derivation of dark energy density [19] we noted that a transition from classical geometry to hyperbolic geometry mark a transition from $E = mc^2$ to $E = E(O) + E(D) = mc^2$ where $E(O) = (\phi^5/2)\, mc^2$ is the ordinary energy density, $E(D) = (5\phi^2/2)\, mc^2$ is the dark energy density, ϕ^5

is Hardy's quantum entanglement [20] and $\phi = 2/(\sqrt{5}+1)$ is the topological speed of light [10,11], [19,20]. This hyperbolic dissection of $E = mc^2$ which offers a possibility to see the transfinite-fractal inside of a superficially smooth outside geometry is a first hint that Rindler's space is more than an analytically clever step needed to understand the behaviour of an observer near to the horizon of a black hole [21-23]. In fact it is this connection to black holes physics which as will be seen shortly, provides the logical inference from the reality of the measured increased rate of cosmic expansion to the physical reality of Hawking's negative energy vacuum fluctuation [20], Unruh temperature [10,16] and dark energy [10, 11,13]. This is all apart from seeing the overall relation to the Planck scale [24] and quantum wave collapse [25].

The present short paper written mainly to argue for the physical reality of the Unruh temperature and Hawking vacuum fluctuation, cannot be self contained and we will not provide a full discussion of Rindler space and its relation to black holes physics due to space limitation. The best we can do here is to refer the reader to the excellent extensive literature on the subject [16-18]. We could envisage the situation as a wedge located inside the light-cone. In the present derivation we only take advantage of the main established results, namely that we have left and right of the Rindler wedge observer a horizon akin to that of a black hole and that he or she will see Unruh's thermal temperature [16-18]. We will be concerned with correlated events in the hyperbolic triangular part of the Rindler wedge (see for instance Fig. 1.2, page 9 of Ref. [16]) and note how it relates to the hyperbolic projection of the bulk (given by the exceptional Lie symmetry group E8E8 as explained in Ref. 20), i.e. the holographic projection. This projection resembles an Escher limit circle given by the compactified Klein-modular curve with SL(2,7) symmetry group or Penrose's noncommutative fractal universe with its von Neumann-Connes dimensional function $D = a + b\phi$ where $a, b \in \mathbb{Z}$ and $\phi = 2/(\sqrt{5}+1)$ [20]. The limit circle of the boundary of this hyperbolic space which lies theoretically at infinity relates to the feature of negative repulsive gravity at the edge of the universe, or anticlastic curvature shown in Fig. 14 of Ref. [20]. That means Hawking's negative energy vacuum fluctuation and its connection to the Unruh temperature of the Rindler wedge is now clear. It is the main task of the present work to show how we can use all the preceding facts to deduce E(O) and E(D) and show that the sum is equal to E(Einstein) which we do in the next section. Since our derivation of these equations describing the physical real observed and measured cosmic expansion is based on the Rindler wedge, then this wedge must also be real and it follows suit that Unruh's temperature and Hawking's fluctuation are equally real and by no means a mathematical artefact.

2. Analysis

Consider the near horizon Rindler coordinate system and the resulting Rindler space wedge [16-18]. The "wedge" region labelled in [16] as region I is formed by two lines halving the upper and lower quarters of the right hand side of the chart as can be seen in Fig. 1.2 of [16]. The side lines of the wedge are the Rindler horizon and we note that region I is the only region of the four regions of the Rindler chart which is outside the corresponding black hole [16-18], [21-23]. All the parameterized world lines within the Rindler wedge are obviously a family of hyperbola so that a vertical line perpendicular to x and located as near as possible to the origin of the chart will form with the two $\pm 45^{\circ}$ inclined horizons a triangle enclosing an area with the subtle fact of being by construction Lorentz invariant [16-18]. Furthermore the inverse of the constant Rindler acceleration is a radius for all points of a world line. Consequently the constant acceleration is the curvature of a time-like world line while the hyperbolic angle will turn out to play the role of a mass. It is then not difficult following for instance Figs. 4.30 and 4.31 of [17] or Figs. 1.2 to 3.4 of [16] to see that the area of the hyperbolic triangular part of the larger triangular Rindler wedge is given by

$$A_o = \frac{1}{2} ab^2 \tag{1}$$

where $a = m_o$ and $b = c_o$. Here m_o will turn out to be a topological "hyperbolic" mass and c_o is the topological speed of light in a unit interval Cantorian universe [11, 13, 25]. On the other hand and on normalizing the total Rindler triangular wedge, the circular section shaped area which completes the hyperbolic triangular area A_o to the entire Rindler area $A_R = 1$ is clearly given by

$$\begin{aligned} A_D &= 1 - \frac{1}{2} ab^2 \\ &= 1 - \frac{1}{2} m_o c_o^2. \end{aligned} \tag{2}$$

Note that the standard notation used by Susskind is $b \equiv \rho$ and $a \equiv \omega$ where ρ is the inverse of Rindler constant acceleration and ω is a relevant hyperbolic angle [16]. There are various sophisticated avenues to arrive at $m_o = \phi^3$ and $c_o = \phi$ where $\phi = 2/(\sqrt{5}+1)$ as discussed independently of the present Rindler space based analysis for instance in [11] and [25]. However it seems to us that the simplest way to convince ourselves with these values is to remember that negative energy fluctuation at event horizon coupled with the basic Cantorian nature of quantum spacetime [11, 25] generates the Unruh thermal temperature which the Rindler observer sees [16-18]. This is done via a Van der Waals or à la Hawking radiation manner generating a topological mass equal to the intrinsic quantum entanglement of the Cantorian quantum spacetime given by setting n = 0 in the general formula of entanglement [10, 11, 13]

$$P^{(n)} = \phi^{3+n}. \quad (3)$$

Consequently

$$P^{(0)} = \phi^{3} = m_o. \quad (4)$$

is the mass corresponding to the Unruh-like microwave background fluctuation, i.e. radiation. On the other hand the arguments leading to $c_o = \phi$ were given in detail in previous publications, notably [1, 11 and 24]. Inserting in A_o and A_D we find the expected result

$$A_o = \phi^5/2 \quad (5)$$

and

$$A_D = 1 - (\phi^5/2) = 5\ \phi^2/2 \quad (6)$$

as well as

$$A_o + A_D = 1 \quad (7)$$

where ϕ^5 is the famous Hardy quantum entanglement which may be interpreted also as the topological Planck energy while half this value is a topological hyperbolic Planck triangle akin to the triangles of the compactified Klein modular curve and leading to a Regge-like fractal triangulation [11, 20]. We note on passing that m(D) = 5 is the five dimensional Kaluza-Klein topological mass [1, 11, 24]. To obtain the corresponding physical energy densities we need to multiply the areas with mc^2 and find [20, 25]

$$E(O) = (\phi^5/2)(mc^2) \cong mc^2/22, \quad (8)$$

$$E(D) = (5\ \phi^2/2)(mc^2) \cong mc^2\,(21/22) \quad (9)$$

and of course the final sum

$$E(O) + E(D) = mc^2 = E(\text{Einstein}) \quad (10)$$

in full agreement with all known accurate cosmological measurements [1-15] and our previous theoretical derivations [24, 25].

3. Discussion and Intermediate Conclusion

Pondering what we did in the present work we realize that we have not just given yet another derivation based on Rindler space reinforcing previous ones. The fact is that we have done here with the present analysis far more than any previous derivations [1, 10, 11, 13, 19, 20, 24, 25]. This is so because we have effectively proved that Hawking's negative vacuum energy fluctuation and Unruh's temperature are physical, real and have important observational consequences and are not just mathematical constructions. The obvious logical chain of reasoning leading to this conclusion is as follows: by proving that dark energy is real by virtue of our theory and the accurate measurement of increased cosmic expansion which has convinced the overwhelming majority of scientists of its reality, then by the same token, Hawking's fluctuation and Unruh temperature must be physical and real. The present derivation has clearly shown that our tested and measured theoretical results are part and parcel of the Rindler-Unruh effects. Stated in the simplest of terms, Unruh temperature, Hawking's fluctuation, dark energy, repulsive gravity at the edge of the universe and acceleration rather than decelerating cosmic expansion are various facets of the very same physical reality. This is actually not that surprising if we remember what the universe looked from the "outside" like in the Penrose fractal tiling universe projection [32]. It is actually a black hole albeit an unimaginably gigantic one. From this view point, Hawking's negative energy fluctuation and dark energy are identical. Of course it is debatable if there is an "outside" for the universe although that is what the Wheeler-Dewitt equation is all about [22, 32].

It is a remarkable turn of fortune that based on the painstaking experimental work of the five Nobel Laureates of COBE, WMAP and type 1a supernova who used the entire universe as an experimental set up [2-9], things which were regarded not really so long ago as theoretical curiosities or farfetched as well as obscure physical possibilities have become real and of truly profound value for science.

4. Concluding Remarks

It was an occasional rightful question to ask if Unruh's mathematical thermalization will lead to actual physical radiation [26,27]. The present work answers this question affirmatively although indirectly because the increased cosmic expansion is real and the overwhelming majority of experimental and theoretical scientists agree that it is real. Consequently and by virtue of the present analysis based on Rindler's spacetime and predicting with incredibly high accuracy the measured data, the Unruh radiation, Hawking radiation and closely related effects such as the Sokolov-Ternov effect [27] are all real and could be measured in principle in the not too distant future. In fact it could have been measured already without the knowledge of the wider scientific community, maybe out of fear of opposition which can sometimes take severe forms. The main direction of the work upon which the present papers is based is geometrizing physics via transfinite geometry and abstract topology [28-36]. We think we have revealed in previous works the geometry of quantum mechanics [28] and quantum entanglement. We hope that the present work goes some way towards geometrizing the entirety of high energy particle physics [32, 34, 35].

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