Solution of the Horizon and Flatness Problem in Cosmology without Inflation

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Abstract: It is shown that the hypothesis of an inflationary universe to solve the horizon and flatness problem can be avoided by Lorentzian relativity assuming the existence of a preferred reference system at rest with the zero point vacuum energy cut off at the Planck energy. Under this assumption there will be a "firewall" at the event horizon of an expanding universe where all matter disintegrates into radiation having everywhere the Unruh black body radiation temperature. The replacement of the Einsteinian relativity by the Lorentzian relativity to solve the problem of quantum gravity was suggested to the author by Heisenberg.

1. Introduction

The observed uniformity of the cosmic microwave background radiation showing an almost perfect display of Planck's radiation law has been a great mystery, as was the observed flatness of the universe obtained by the counting of galaxies. Of much less importance is the absence of magnetic monopoles depending on unproven elementary particle physics theories. It was shown by Guth [1] that all three unsolved problems could be explained by the extremely rapid 10^{78} fold (inflationary) expansion of the universe from a small causally connected universe. Apart from solving the horizon problem posed by the uniformity of the cosmic background radiation, the rapid expansion would iron out small irregularities explaining the observed flatness of the universe, which is not a 3-dimensional space of constant curvature. And it would also explain the absence of magnetic monopoles produced during the "big bang," simply by their dilution to unobservable levels.

It is shown that with Lorentzian relativity of the pre-Einstein theory of relativity by Lorentz and Poincaré the observed material can be explained without inflation as well. What has been called Lorentzian relativity refers to the pre-Einstein theory of relativity by Lorentz and Poincaré. It still assumed the existence of an ether, found by Einstein superfluous with his postulates. However, through quantum mechanics and its zero point vacuum energy, a "transmogrified" ether had to be reintroduced into physics.[1] It is Lorentz-invariant for energies small compared to the Planck energy.

2. Einsteinian versus Lorentzian relativity

While Lorentzian relativity explains the experimental material as well as Einsteinian relativity, differences between them show up at extremely high energies. The principal difference between Einsteinian and Lorentzian relativity is that the latter has a preferred reference system. Through a preferred reference system something absolute enters the theory, absent in Einstein's special theory of relativity, and by implication in his general theory of relativity. This absolute element is the maximum absolute velocity against this preferred reference system. In this

[1] That the zero point vacuum energy is a kind of an ether was first recognized by Nernst, and it can replace the ether in the Lorentz-Poincaré pre-Einstein theory of relativity.

preferred reference system the maximum velocity is the velocity of light. In Einstein's theory the constancy of the velocity of light in all inertial reference systems is the result of his clock synchronization convention which excludes the measurement of the one-way velocity of the light. Poincaré uses this convention too, but because he still assumes the existence of a preferred reference system he must introduce an additional postulate which is that all objects suffer a true contraction equal to $\ell = \ell_0 \sqrt{1 - v^2/c^2}$ against the preferred reference system. And Lorentz, in his electron theory, finds a plausible explanation for this contraction effect to result from a flattening of the electrical potential surfaces by an electron in an absolute motion against the ether, which is the same as the absolute motion against a preferred reference system.

There then, for velocities larger than the velocity of light, an elliptic differential equation for the equipotential surfaces, responsible for the equilibrium of matter, goes over into a hyperbolic differential equation where no equilibrium solutions are possible.

A decision between the interpretation of Einstein and Lorentz-Poincaré could be made at particle energies approaching the Planck energy at 10^{19} GeV. Compared to the 10^3 GeV of the Large Hadron Collider, this energy is 16 orders of magnitude larger. It is therefore out of reach for particle accelerators, but not for black holes. At the event horizon of a black hole, a particle would reach an infinite energy in an infinite time. But if it only has to reach the Planck energy, this time is finite and well within the time needed to observe the decay of matter into radiation in approaching an event horizon.

3. The Minkowski Space-Time as a Consequence of Quantum Mechanics

According to quantum mechanics each mode of the electromagnetic field with the frequency ω has the zero point energy

$$\varepsilon_0 = \frac{1}{2}\hbar\omega \tag{1}$$

From there one obtains the frequency spectrum $f(\omega)$ of the quantum mechanical zero point vacuum energy by multiplying (1) with the volume element in frequency space $4\pi\omega^2 d\omega$:

$$f(\omega)d\omega = \text{const} \cdot \omega^3 d\omega \tag{2}$$

With $c = \omega / k$ one has

$$f(\omega)d\omega = \text{const} \cdot d\omega^4 \tag{3}$$

or in wave number space $k = k_1, k_2, k_3, k_4$, where $k_4 = i\omega / c$,

$$f(k)dk = \text{const} \cdot dk^4 \qquad (4)$$

where $dk^4 = dk_1, dk_2, dk_3, dk_4$ is the Lorentz invariant volume element in four-dimensional momentum space. It thus follows that (2) is Lorentz invariant.

The importance of this result is that quantum theory through its zero point vacuum energy “generates” from the three dimensions of space and one dimension of time the Minkowski space-time and by implication the special theory of relativity.

With the zero point energy cut off at the Planck length $l = \sqrt{\hbar G / c^3} \sim 10^{-33} cm$, that is, at the Planck energy $E_p = \sqrt{\hbar c^5 / G} \sim 10^{19} GeV$, Lorentz invariance is violated, establishing a preferred reference system in which the zero point energy is at rest.

The argument that the space curvature at the event horizon is small and that for this reason quantum gravity can there be ignored is not valid with the zero point vacuum energy cut off at the Planck energy, because at 10^{19} GeV in the preferred reference system, an elementary particle is subject to the space curvature at the Planck length, which by the quantum fluctuations of the space-time can there be large. The space-time curvature near the Planck length requires a more detailed analysis. The widely accepted assumption that at the Planck length space-time is a kind of turbulent space-time foam [2], is likely wrong. As it was first noticed by Sakharov [3], this assumption implies a huge cosmological constant about 120 orders of magnitude larger than what is observed. Because of it, Sakharov proposed the hypothesis that the vacuum of space is occupied by an equal number of Planck mass particles (“maximons”) and compensating “ghost” particles, which must be negative mass Planck mass particles. A vacuum filled with positive Planck mass particles only, would also be unstable [4]. Following Sakharov’s proposal, the author has made the hypothesis that the vacuum of space is a kind of plasma made up of positive and negative Planck mass particles in equal numbers [5], and it was shown by Redington [6], that such a configuration leads to stable solutions of Einstein’s gravitational field equations, describing a literal rippling of space-time. This hypothesis also satisfies the average null energy condition of general relativity, with all particles composed of positive and negative masses, with the gravitational field mass providing their observed positive mass [7,8].

4. Derivation of the de Sitter Space from Lorentzian Relativity

The observed flatness of the universe can with reasonable accuracy be described by setting $\Omega = 1$[9], with the radial expansion velocity

$$v = Hr = (r/R)c \qquad (5)$$

where $H = c/R$ is the Hubble constant and R the world radius.

In Lorentzian relativity rods suffer a true length contraction and slower going clocks (ultimately made from rods), a likewise true time dilation. Therefore, the transformation of the Minkowskian line element for an observer in an initial reference system

$$ds'^2 = c^2 dt'^2 - dr'^2 \tag{6}$$

into a reference system at rest with the zero point vacuum energy where $dr = dr'\sqrt{1-v^2/c^2} = dr'\sqrt{1-r^2/R^2}$ and $dt = dt'/\sqrt{1-v^2/c^2} = dt'/\sqrt{1-r^2/R^2}$ changes (6) into

$$ds^2 = (1-r^2/R^2)c^2 dt^2 - \frac{dr^2}{1-r^2/R^2} \tag{7}$$

This is the line element of a de Sitter space with an event horizon at the world radius R. The large R explains the flatness of the universe in Lorentzian relativity.

5. Disintegration of Matter crossing the Event Horizon in the Lorentzian Interpretation

Because the zero point vacuum energy is cut off at the event horizon, where the Planck energy for an infalling elementary particle is reached, Lorentz invariance is violated near the event horizon and matter can cross the event horizon. However, because in the Lorentzian interpretation matter is held in a stable equilibrium by differential equations which for energies below the Planck energy are elliptic, but hyperbolic for energies above the Planck energy, where no such equilibrium is possible, matter disintegrates in crossing the event horizon.

The transition from an elliptic to a hyperbolic differential equation in crossing the event horizon can be explained by a simple example in electrostatics. In the Lorentzian interpretation the electrostatic potential ϕ in the preferred reference system is given by

$$\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} + \frac{\partial^2\phi}{\partial z^2} = -4\pi Q \tag{8}$$

where Q is the distribution of electric charges, but in a reference system moving with the absolute velocity v in the x-direction against the preferred reference system, it is given by

$$\left(1-\frac{v^2}{c^2}\right)\frac{\partial^2\phi'}{\partial x'^2} + \frac{\partial^2\phi'}{\partial y'^2} + \frac{\partial^2\phi'}{\partial z'^2} = -4\pi Q(\bar{r}') \tag{9}$$

Setting $\partial x' = \sqrt{1-v^2/c^2}\,\partial x$, $\partial y' = \partial y$, $\partial z' = \partial z$, $\phi' = \phi$, (9) becomes equal to (8). It remains an elliptic differential equation only for $v < c$, while for $v > c$ it becomes hyperbolic.

Having reached the event horizon where the Lorenz invariance is destroyed, matter is subject to the Einstein-Hopf friction force given by [10]

$$F = -\mathrm{const} \cdot \left[f(\omega) - \frac{\omega}{3} \frac{\partial f(\omega)}{\partial \omega} \right] \cdot v \tag{10}$$

where $f(\omega)$ is the spectrum of the radiation field causing the friction force and v the velocity of a particle moving through this field. One immediately sees that $F = 0$, if $f(\omega) \propto \omega^3$ as it is given by (2). But if it is cut off at the Planck frequency $\omega_p = c / r_p$, then one has $F \neq 0$ for $\partial f(\omega) / \partial \omega = 0$ at the cut off frequency.

Applied to a Planck mass particle moving with the velocity $v = c$ through zero point energy field of the positive-negative mass Planck mass plasma, the friction force is then

$$F = -\frac{2}{5} \frac{(\hbar c)^2}{m_p c^2} \left(\frac{\omega_p}{c} \right)^3 = -\frac{2}{5} \frac{(\hbar c)^2}{m_p c^2} \frac{1}{r_p{}^3} \tag{11}$$

where m_p and r_p are the Planck mass and length connected by $m_p r_p c = \hbar$. From (11) one obtains for the acceleration (deceleration) at the cut off frequency $\omega = \omega_p = c / r_p$

$$|a| = \frac{F}{m_p} = \frac{2}{5} \frac{c^2}{r_p} \tag{12}$$

Inserting this value of $|a|$ into the expression for the Davies-Unruh temperature T_u [11,12,13]

$$kT_u = \frac{\hbar |a|}{2\pi c} \tag{13}$$

one finds that

$$kT_u = \frac{1}{5\pi} m_p c^2 \tag{14}$$

up to the factor $1/5\pi$ equal to the Planck temperature at the Planck scale. This temperature is universal explaining the uniformity of the cosmic microwave background radiation without the assumption of inflation.

The replacement of inflation with the black body radiating event horizon at the world radius where $v \to c$ seems to require at least a small acceleration, which in fact is observed and can be expressed by a small cosmological constant. The observed 4K blackbody microwave radiation is then simply the Doppler-shifted radiation emitted at the event horizon.

The origin of a small positive cosmological constant can be explained by a small excess of negative over positive masses in the system of all observed galaxies inside the event horizon of the world radius R. The world radius would there be the Debye length of the conjectured positive-negative mass Planck mass plasma [7]. There the repulsive negative masses would drive a gravitational expansion, as an attractive positive mass would drive a gravitational collapse. The observed system of galaxies would just fill one Debye cell of a much larger system of galaxies, or a metagalaxy, outside the world radius of the observed galaxies, with an equal number of them having a surplus in positive or negative mass, with those having a positive surplus collapsing, and those with a negative surplus expanding.

6. Discussion

It is instructive to compare the cosmological event horizon with the event horizon of a black hole. For both of them the velocity of light is reached, and in both cases matter would disintegrate. The fate of matter in approaching the event horizon of a black hole has most recently attracted great interest [14], with the conclusion that these three pillars of physics: 1. The general theory of relativity; 2. Quantum mechanics; and 3. Quantum field theory cannot all be correct. Quantum theory is a theory for all objects, with Einstein's theory of gravitation, Maxwell's electrodynamic field theory, Bohr's theory of the atom, et al., different objects, but all of them without exception subject to the laws of quantum mechanics. From this perspective quantum mechanics has precedence, and with it the quantum mechanical doctrine of unitarity, violated in Hawking's black hole theory. It was for this reason that the existence of a "firewall" at the event horizon was proposed by Almheiri, Marolf, Polchinski, Stanford and Sully [15], excluding the formation of a black hole and thereby saving quantum mechanical unitarity. An explanation how the firewall can actually be formed was not given. With the emission of radiation at the event horizon it would have to involve quantum mechanics, but because for a large black hole the space curvature at the event horizon is quite small, one might think that quantum gravity cannot be the cause of it. However, this ignores the quantum mechanical zero point vacuum energy, leading to a preferred reference system in which this energy is at rest, and a violation of Lorentz invariance at the Planck length in the preferred reference system. This makes it possible for matter to cross the event horizon, which in the Lorentzian interpretation is a crossing from a region where all matter is held in a stable equilibrium by potentials derived from an elliptical differential equation into a region where the corresponding equations are hyperbolic where no such equilibrium solutions exist. This idea provides a simple explanation for the observed most powerful gamma ray bursts [16], for which all other proposed models fail. Such an assumption though invalidates the general theory of relativity but only at extremely high energies near the Planck energy. The introduction of a preferred reference system introduces an absolute element, which is the absolute velocity against this reference system. It is against the spirit of the general and special theory of relativity, but becoming important only near an event horizon, be it the event horizon of the expanding universe or of a black hole. Apart from these extravagant conditions, the general and special theory of relativity remain extremely good approximations, including the energies of ~10^3 GeV reached at the Large Hadron Collider, which are about 16 orders of magnitude smaller than the Planck energy of 10^{19} GeV.

Conclusion

It is shown that the uniformity of the cosmic microwave background radiation and with it the cosmic horizon problem, does for its solution not require such an extravagant assumption as an inflationary expansion by 78 orders of magnitude. It rather has a much more simple explanation by Lorentzian relativity, unlike Einsteinian relativity still assuming a preferred reference system, established by the zero point vacuum energy cut off at the Planck length. It is this cut off zero point vacuum energy which replaces the ether, discarded by Einstein.

The proposal to replace the inflationary assumption with something less extravagant is not the only one. A different alternative proposed by Alfvén [17] was that the microwave background radiation comes from regions of the metagalaxy where galaxies made of matter get in contact with galaxies made of antimatter. The boundary between those neighboring galaxies would by the annihilation of matter with antimatter form a repulsive Leidenfrost-effect-type layer, preventing the matter and antimatter galaxies from mixing and mutually annihilating each other.

References

[1] A. Guth, The Inflationary Universe: The Quest for a New Theory of Cosmic Origins, Basic Books, pp. 223-234 (1997).

[2] J. A. Wheeler, Topics in Nonlinear Physics, Proceedings of the Physics Session International School of Nonlinear Mathematics and Physics, Edited by N. J. Zabusky, Springer Verlag, New York, 1968, p.649.

[3] A. Sakharov, Doklady Akademii Nauk SSSR, vol. **177**, 77-71 (1967).

[4] I. A. Redmount and Wai-Mo Suen, Phys. Rev. **47**, R 2163 (1993).

[5] F. Winterberg, Z. Naturforsch. – Physical Sciences **43a**, 1 (1988).

[6] N. Redington, arXiv: gr-qc/9701063.

[7] F. Winterberg, Z. Naturforsch. **58a**, 231 (2003).

[8] F. Winterberg, Phys. Scr. **85** (2012) 055003.

[9] E.W. Kolb and M.S. Turner, The Early Universe, Addison Wesley, Redwood City, California, 1990, p.

[10] A. Einstein and L. Hopf, Ann. Physik **33**, 1105 (1910).

[11] S.A. Fulling (1973). *Physical Review D* **7** (10): 2850.

[12] P.C.W. Davies (1975). *Journal of Physics A* **8** (4): 609.

[13] W.G. Unruh (1976). *Physical Review D* **14** (4): 870.

[14] A. Almheiri, D. Marolf, J. Polchinski, and J. Sully. JHEP 02 (2013) 062.

[15] A. Almheiri, D. Marolf, J. Polchinski, D. Stanford and J. Sully. JHEP 09 (2013) 018.

[16] F. Winterberg, Z. Naturforsch. **56a**, 889 (2001).

[17] H. Alfvén, Astrophysics and Space Science, **89**, 313 (1963).