Volume 15 Issue 38
Originally issued as A6

Global Journal of Science Frontier Research: A
Physics and Space Science
Volume 15 Issue 6 Version 1.0 Year 2015
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

PCT Symmetric Black Hole Radiation from Semiclosed Friedman Universe and Zitterbewegung of Radiating Particle

By Noboru Hokkyo
Senjikan Institute, Japan

Abstract- Einstein's early thought experiment of a tiny clock ticking (quantized) around a closed loop in Newton potential−GM/r (gravitational Bohr atom), is revisited and its cosmological implication is considered by first replacing the point mass M by a magnetc flux confined within a slender tube standing perpendicular to the plane of the paper, indicating probable existence of a pair of magnetic monopoles at the north and the south poles of the double-valued Friedman universe projected on 2-dimensional plane. The clock is next replaced by a wavelike test particle ticking with Planck period and the Newtonian mass M by a Planck scale proper mass of the semiclosed Friedman black hole joined onto asymptotically flat outer space in early and later inflationary epochs of expanding and contracting universe, emitting radiation from P (left-right)-C (particle-antiparticle) and T(future-past) symmetric path of the test particle zigzagging in time (Zitterbeweging). A direct imaging of trembling motion of a laser-activated ion clock trapped by strong electrodynamic potential in Bose-Einstein condensates, simulating Dirac's monopole and Zitterbewegung, followed by energy emission, simulating Hawking radiation, is briefly mentioned.

Keywords: *quantum theory, general relativity, cosmology, black hole, dark energy.*

GJSFR-A Classification : *FOR Code: 020199*

PCTSYMMETRICBLACKHOLERADIATIONFROMSEMICLOSEDFRIEDMANUNIVERSEANDZITTERBEWEGUNGOFRADIATINGPARTICLE

Strictly as per the compliance and regulations of :

© 2015. Noboru Hokkyo. This is a research/review paper, distributed under the terms of the Creative Commons Attribution-Noncommercial 3.0 Unported License http://creativecommons.org/licenses/by-nc/3.0/), permitting all non commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

PCT Symmetric Black Hole Radiation from Semiclosed Friedman Universe and Zitterbewegung of Radiating Particle

Noboru Hokkyo

Abstract- Einstein's early thought experiment of a tiny clock ticking (quantized) around a closed loop in Newton potential −GM/r (gravitational Bohr atom), is revisited and its cosmological implication is considered by first replacing the point mass M by a magnetc flux confined within a slender tube standing perpendicular to the plane of the paper, indicating probable existence of a pair of magnetic monopoles at the north and the south poles of the double-valued Friedman universe projected on 2-dimensional plane. The clock is next replaced by a wavelike test particle ticking with Planck period and the Newtonian mass M by a Planck scale proper mass of the semiclosed Friedman black hole joined onto asymptotically flat outer space in early and later inflationary epochs of expanding and contracting universe, emitting radiation from P (left-right)-C (particle-antiparticle) and T(future-past) symmetric path of the test particle zigzagging in time (Zitterbeweging). A direct imaging of trembling motion of a laser-activated ion clock trapped by strong electrodynamic potential in Bose-Einstein condensates, simulating Dirac's monopole and Zitterbewegung, followed by energy emission, simulating Hawking radiation, is briefly mentioned.

Keywords: quantum theory; general relativity; cosmology; black hole; dark energy.

I. Introduction

In previous discussions[1,2]we considered a formation of Planck scale black holes in early and later stages of the expanding and contracting semiclosed Friedman universe joined onto asymptotically flat outer spaces through Schwarzschild bottleneck. We here consider a gravitational Bohr atom as a model of the metastable Friedman black hole emitting radiation on the background of perturbed cosmic radiation. PCT-symmetric interpretation of Hawking radiation from the Planck scale test particle zigzagging in time (zitterbewegung) on the event horizon is also given.

II. Einstein's Clock and Monopole

In an attempt to incorporate electromagnetism into general relativity, Weyl[3] proposed in 1918-9 an idea of spacetime dependent scale variations of particle paths. But Einstein[4] rejected the idea and proposed a thought experiment: Consider two clocks ticking around their respective loops L_1 and L_2. The Newton potential $-GM/r$ of a point mass M is contained in the loop L_2. These clocks, originally identical at O, would go at different speeds after they brought about their respective loops and meet at the starting point O. Thus: "The length of a common ruler or the speed of a common clock would depend on its history."[4] A common clock with mass m ticking along the hyperboloid of world lines with spatial period $l_m = \hbar/mc$ crossing the time axis at $ct = l_m$ of the light cone was considered by Penrose.[5]

Later in 1986 Yang[6] replaced Einstein's clock by an electron and M by a magnetic flux Φ confined within a slender tube standing perpendicular to the plane of the paper, and emphasized the role of the integral around the loop as the phase factor (wave function) in quantum mechanics:

$$\exp i\oint \mathbf{A}d\mathbf{r} = \exp i\Phi, \qquad (1)$$

explaining visible Aharonov-Bohm (AB) interference fringes on the detector plane, restricting Maxwell's vector potential $\mathbf{A}$ to have discrete values in double-connnected space or all space minus r = 0:

$$e\oint \mathbf{A}d\mathbf{r}/hc = e\Phi/hc = n = \text{integer}, \qquad (2)$$

telling that the AB experiment is dependent only on the flux modulo hc/e:

$$\Phi(\text{modulo } hc/e). \qquad (3)$$

The magnetic monopole having magnetic charge $g = hc/e$, predicted by Dirac[7] in 1931 by considering a magnetic flux crossing a cap bounded by a closed loop, was recently created experimentally as an electrodynamically stimulated ion clock confined within strong Coulomb potential in super-cold spinor Bose-Einstein condensate and spin ice.[8]

We note that the semiclosed Friedman universe, contracting and expanding between asymtotically flat outer spaces, can be projected onto 2-dimenional plane of the paper: evolutionarily earlier upper hemishere filled with dark energy and the evolutionarily later lower hemisphere filled with dark matter underneath the paper with probable existence a pair of magnetic monopoles at the north and the south poles of the double-valued Friedman universe, connected or diconnected, by Dirac string.

Author: Senjikan Institute, Niigata, Japan.
e-mail: noboruhokk@yahoo.co.jp

© 2015 Global Journals Inc. (US)

III. Nambu's Mass Formula

Dirac considered a magnetic monopole of charge g creating a magnetic flux Φ crossing a cap bounded by a closed loop, getting the mass spetrum of the monopole.

$$m_{mono} = n(\hbar c/2e), \quad n = \text{integer}, \tag{4}$$

Numbu's similar mass formula[9] was proposed for elementary particles discovered before 1952: μ, π, K, τ (mesons), P/N (proton/neutron), Λ, Σ, Ξ, Ω, Λ_c (baryons):

$$m_n = n(\hbar c/2e^2)m_e$$

$$= (137n/2)m_e,\ m_e = \text{electron mass},$$

$$n = 3, 4, 14, 15, 16, 17, 18, 19, 24, 33 \tag{5}$$

as "a convenient aid to memory." The relation (5) was reexpressed as[10]

$$m_n c^2 = (n/2)(\hbar c/L),$$

$$= (n/2)Gm_{pl}^2/L, \tag{6}$$

where $m_n c^2$ is the relativistic rest energy of relatively stables "point-like particles"[11] around us; $L = e^2/mc^2$ is the classical electron radius and m_{pl} the Planck mass, relating classical electrodynamics, quantum theory, relativity and Plackian cosmology.

IV. Stellar Mass and Hawking Temperature

A typical stellar object has a mass[12]

$$m_{stellar} \sim (m_{Pl}/m_p)^2 m_{pl}$$

$$= (l_P/l_{pl})^2 m_{pl} \sim 10^{33}g, \tag{7}$$

where

$$m_{pl} = (c\hbar/G)^{1/2} \sim 10^{-5}g \tag{8}$$

is the Planck mass; $l_P = \hbar/m_{pl}c \sim 10^{-33}$cm the Planck lengh; $m_p \sim 10^{-24}$g and $l_P = \hbar/m_P c \sim 10^{-12}$cm are the proton mass and wavelength, $(l_P/l_{pl})^2 \sim 10^{38}$ being the number of Planckeons contained on the surface of the proton or the holographic information content of the proton related to entropy $S = \pi\kappa(l_P/l_{pl})^2$, where κ is the Boltzman constant. That is, the most stable point-like particle, proton, has entropy,

Consider Hawking radiation[13,14]of the Schwarzschild black hole of a typical cosmological object, static or collapsing, with Newtonian mass M, radius R and gravitational radius $r_g = 2GM/c^2$. Then the Hawking temperature T_H is given by

$$T_H = \hbar c/\kappa r_g = Gm_{pl}^2/\kappa R.$$

$$= 10^{-28}K \tag{9}$$

for $R = H/c = 10^{28}$cm, the radius of the universe expanding with Hubble velocity H. The maximum tempeature

$$T_{max} = Gm_{pl}^2/\kappa l_{pl}$$

$$\sim 10^{32}K = (R/l_{pl})^2 T_H. \tag{10}$$

is obtained for $R = R_p = l_{pl}$, realized by almost closed Friedman universe with proper radius $R_p \sim l_{pl}$ and mass $M_p \sim m_{pl}$ having holographic information contents $(R/l_{Pl})^2 = 10^{120}$.

V. Holographichic Hypothesis

The holographichic hypothesis states that, "If $V = 4\pi R^3/3$ is the region of space with boundary surface $\delta V = 4\pi R^2$, there is a description of nature in which all the information contents of the black hole is stored outside the imaginary surface just outside the event horizon of the black hole in degrees of freedom."[15] The number $(R/l_{Pl})^2$ is regarded as the number of Planckeons on the surface of the event horizon of the semiclosed Friedman universe, joined onto aymptotically flat outer space through Planck scale Schwarzschild bottleneck, a topological structure developped in the Planck scale Lorentz sphere at the poles of the universe allowing spacelike hyperboloid extending to asymptotically flat outer space. The present Big Bang universe is regarded to have expanded from a timelike hyperboloid in Lorentz sphere at the north pole of evolutionarily earlier upper hemisphere of the universe. But it is conceivable that the universe arose from a collision between spacelike hyperboloids where a timelike 3-vector is undefined.

VI. Radiation from Friedman Black Hole

The semiclosed Friedman universe was intended to explain the origin of extragalactic quasistllar radio sources with large radius and mass defect filled with low density dust-like matter or dark energy. We here consider a Planckeon as a test paticleon on the surface of the Friedman universe having Newtonian mass M and radius R forming a gravitational Bohr atom described by the radial line element

$$ds^2 = g_{rr}c^2dt^2 - g_{rr}dr^2 \tag{11}$$

where

$$g_{tt} = g_{rr}^{-1}$$

$$= 1 - r^2/r_g^2 + L^2/(m_{pl}c^2 r)^2$$

$$= 1 - r^2/r_g^2 + L^2 l_{pl}^2/r^2. \tag{12}$$

Here $r_g = 2GM/c^2 = R$ for closed universe, $R < r_g$ for semiclosed universe. $R = r_g/2$ is the equator dividing lower and upper hemispheres of the univese joined respectively onto asymptotically flat outer spaces through Schwarzschild throat $(0 < R < r_g/2)$ and double-valued bottleneck $(r_g > R > r_g/2)$.
The angular momentum

© 2015 Global Journals Inc. (US)

$$L = m_{pl}r^2d\theta/dt \quad (13)$$

is quantized as

$$L^2 = l_\theta(l_\theta + 1),\ l_\theta = \text{integer}. \quad (14)$$

The kinetic (free) energy of the test particle moving on the elliptic Bohr orbit is given by

$$E_\theta = (1 - g_{tt}^{1/2})m_{pl}c^2. \quad (15)$$

where $g_{tt}^{1/2}m_{pl}c^2$ is the proper rest energy of the Planckeon for local observer. This energy is liberated in the transition from elliptic ($l_\theta >> 1$) to circular ($l_\theta \sim 1$) Bohr orbit.

We notice that the E_θ has two local maxima at $r_B \sim r_g = R = 10^{28}$cm where the light velocity ($ds^2 = 0$) vanishes: $dr/dt = c(g_{tt}/g_{rr})^{1/2} = 0$ and at

$$r_C = (l_\theta l_{pl} r_g)^{1/2} \sim l_\theta^{1/2}10^{-2}\text{cm}, \quad (16)$$

where $dr/dt = c$, to be compared to the radius of the causally related area in inflationary universe:

$$(T_0/T)R = (3/10^{27})10^{28} \sim 30\text{cm} \quad (17)$$

reached after Big Bang when the temperature of the cosmic back ground radiation was $T_C \sim 10^{27}$K compared to the presently observed temperature $T_0 = 3$K.

VII. Black Hole Radiatiion from Zigzagging Particle

Dirac's P (left-right) C (particle-antiparticle) T(future-past) symmetric photon propagator[2,16] D is defined as

$$D(r,t) = \alpha(t)\delta(c^2t^2 - r^2)$$

$$= [\delta(ct - r) - \delta(ct + r)]/r$$

$$= D_{ret} - D_{adv} = D_+ - D_-, \quad (18)$$

where

$$\alpha(t) = t/|t| = 1 \text{ for } t > 0 \text{ and } -1 \text{ for } t < 0 \quad (19)$$

is the step function annihilating a photon incoming from $r = -\infty$ at the origin $r = 0$ of the past light cone $\delta(ct+r)$ and creating another photon on the future light cone $\delta(ct-r)$; D_+ and D_- are the Fourier contributions to D from positive and negative frequency sheets; D_{ret} and D_{adv} are retarded and advanced propagators.

To allow Stückelberg-Feynman[17]interpretation of an antipaticle as a negative energy particle going backward in time, Feynman proposed a PC and T-symmetric propagator which we denote as D_F:

$$D_F = D_{ret} + D_-,$$

$$D_F = D_{adv} + D_+ \quad (20)$$

so that

$$D_F = D_+ \text{ if } t > 0 \text{ and } D_F = D_- \text{ if } t < 0. \quad (21)$$

The role of D_F in "V-shaped bi-directional EPR correlation" P↔S↔Q between events at P and Q, separated by a spacelike distance but sharing a common source at S in the past, was discussed at the 1983 Tokyo conference.[18] We here visualize a PC and T-symmetric interpretation of Hawking radiation by a "Feynman diagram" of a test particle "zigzaging in time against causal wind." There the retarded particle wave $\exp i(\omega t - kr)$ incoming from a source A at $r = -\infty$ with propagator D_{ret} is captured by the gravitational potential of the black hole at B, and from there goes backward in time ($t \rightarrow -t$) by D_- as a negative frequency wave ($\omega \rightarrow -\omega$) $\exp i(|\omega||t| + kr)$ on the left arm of the past light cone of B to meet the advanced wave $\exp i(\omega t + kr)$ incoming at C from the detection point R at $r = \infty$ on the right arm of the future light cone of C; The retarded wave $\exp i(\omega t - kr)$ from C is annihilated by the detector at R by the counter-propagating advanced wave $\exp i(\omega t + kr)$ from R, forming a combined wave $D = D_{ret} - D_{adv} = D_+ - D_- = \exp i\omega t \sin kr$ on the double light cone where the right arm of the future light cone of C and the left arm of the past light cone of R share a common light path between C and R, creating a PC and T symmetric and bi-directional information flow C↔R of Cauchy data at C and R.

To describe the transition B→C going backward in time, we replace the step fuction $\alpha(t)$ (19) by the square (step-up and down) function:

$$\beta(t) = 1 \text{ for } t_B < t < t_C$$

$$= 0 \text{ for } t_B > t \text{ and } t > t_C, \quad (22)$$

creating a particle at B and annihilating the same particle at C. The amplitude of the N-shaped particle transition, A→B→C→R, can be expressed as

$$\int_A^R d\tau = \int_A^B (g_{tt+})^{1/2}cdt \int_B^C (g_{tt-})^{1/2}dt \int_C^R (g_{tt+})^{1/2}cdt$$

$$= \int_A^B d\tau \int_B^C d\tau \int_C^R d\tau$$

$$\rightarrow \int_A^R \exp i[(\omega_A + |\omega_B| + \omega_C)]d\tau. \quad (23)$$

While equation (23) gives a time-dependent spectrum of emitted radiation, the accumulation of successive phase changes in the integral tells that the proper time τ continues to increase with the phase $|\omega||t|$ as one follows the particle path from one scattering point to the next, zigzaggig in time.

VIII. Gravitational Zitterbewegung

To visualize 1-dimensional Zitterbewegung, write the radial line element of Friedman metric as

$$ds^2 = ds_+ds_-$$

$$= (g_{tt+}g_{tt-})^{1/2}c^2dt^2 - (g_{tt+}g_{tt-})^{-1/2}dr^2, \quad (24)$$

where $g_{rr+} = 1 - r/r_g$,

$$g_{tt-} = 1 + r/r_g \quad (25)$$

© 2015 Global Journals Inc. (US)

so that

$$g_{tt} = (g_{tt+}g_{tt-})^{1/2} = 1 - r^2/r_g^2. \quad (26)$$

Here ds_+ and ds_- are line elements going respectively forward (expanding) and backward (contracting) in time. That is, ds has two-sheeted structure represented by 1x2 state matrix $ds = {}^{(ds+}{}_{ds-)}$. The flip-flop between two states is decribed by 2x2 matrix $\sigma = ({}_1{}^1)$ so that $\sigma ds_+ = ds_-$, $\sigma ds_- = ds_+$ and $\sigma^2 = ({}^1{}_1) = 1$.

The transition amplitude between ds_+ and ds_- is

$$<ds_+|E|ds_+> = (r/l_g)^2 \exp(i2E\tau/\hbar). \quad (27)$$

Here $E = (g_{tt+})^{1/2}m_{pl}c^2$ is the local energy varying from 0 to $m_{pl}c^2$ with light velocity $dr/dt = c(g_{tt+})^{1/2} = c/n(r)$ where n(r) is the refractive index of the medium.

Zittebewegung of the test particle is represented by

$$<ds_+|\sigma(\tau)|ds_+> = \exp(i2E\tau/\hbar)$$

$$= 1 \text{ if } 2E\tau/\hbar = 2\pi n, \ n = \text{integer} \quad (28)$$

giving uncertainty relation between E and τ:

$$E\tau = nh. \quad (29)$$

A direct imaging of Zitterbewegung of a super-cold and laser-activated ion clock trapped by strong electrodynamic potential, simulating a black hole, in Bose-Einstein condensates followed by energy emission, simulating the Hawking radiation, was reported recently.[20]

IX. Conclusion

Previous discussions[2,16] of PCT-symmetric and V-shaped EPR correlation is extended to PCT-symmetric black hole radiation from N-shaped zigzagging particle path on the basis of local accuracy of special relativity (weak equivalence) and asymptotic accuracy of Friedman solutions joined onto flat Euclidean space (strong equivalence) of Einstein's general relativity equations including singularities in particle source, detector and event horizons, allowing topological (non-Hasdorff) nature of the Lorentz sphere at the origin of the light cone and the bottleneck structure of the Einstein-Rosen bridge[21] intended to create a particle from the universe.

References Références Referencias

1. N. Hokkyo, Physics and Space Science **14**, 1-3 (2014).
2. N. Hokkyo, International Review of Physics. April **2**-2 2015 (on line).
3. C. N. Yang, in "Herman Weyle's contribution to Physics," in Herman Weyle (Springer, New York) (1986).
4. A. Einstein, in "Remarks at the end of H.Weyl": Sitzungsberichite d.k. Preuss. Akad. d. Wiss, 1918 p.465.
5. R. Penrose, "An Analysis of the Structure of Space-Time," Adams Prize Essay (1966).
6. C. N. Yang, in "Gauge fields, Electromagnetism and Aharonov-Bohm Effect," in Proc. Int. Symp. on Foundations of Quantum Mechanics (ISQM), eds. Physical Society of Japan, Tokyo (1983), pp.5-9.
7. P. A. M. Dirac, Proc. R. Soc. Lond. A33, 60-72,(1931).
8. M. W. Ray, et al. Nature **505**, 637-660 (2014): Early works cited herein.
9. Y. Nambu, Prog. Theor. Phys.755-5 (1952).
10. N. Hokkyo, "Radiationless Zitterbewegung of Dirac particle and mass formula, "Nuovo Cimento **98A** (6), 787-794 (1987).
11. G. t'Hooft, "Is Quantum Field Theory a Theory?" Nishina Memorial Lecture, Tokyo University (1983).
12. S. Weinberg, "Gravitation and Cosmology," Wiley, New York (1971).
13. S. Hawking, in "Quantum Gravity," eds.C. J. Isham, R. Penrose and D. W. Sciama, Clarendon Press, Oxford (1975) pp.219-267.
14. B. S. DeWitt, PHYSICS REPORTS **19**, 295-357 (1975).
15. E. Witten, CURRENT SCIENCE, **81**, No.12, 25 December, .pp.1576-81 (2001).
16. N. Hokkyo, J. Mod. Phys. **5,** 134-7 (2014).
17. E. C. C. Stückelberg, Helv. Phys. Acta **15**, 23-26 (1942).
18. O. Costa de Beauregard, in " Lorentz and CPT Invariances and EPR Correlation," ISQM ibid, pp.233-241 (1983).
19. N. Hokkyo, Studies in History and Philosophy of Modern Physics: Forcus issue on time-symetric aproaches to quantum mechanics, **39**, 762-.766, (2008).
20. L. J. LeBleman et al., New Jounal of Physics **15**(7), 0736011 (on line) (2013).
21. A. Einstein and N. Rosen, "The Particle Problem in the General Theory of Relativity," Phys. Rev. 48, 73-8 (1935).

© 2015 Global Journals Inc. (US)