Article

Binary Systems in Multi-Horizon Universe

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Abstract

In this paper, it is shown that fundamental interactions generate multi-horizon Universe. Comparing these horizons with each other, it is observed that the radius and cross section of gravitational horizon is more and the radius and cross section of colorful horizon is less than other horizons. At last, it has been found that Color repression may create a complication between colorful parts of Universe to shape color singlet binary framework. The cross section for particles inside this system is rising at lower expansion velocity of Universe colorful part, exhibiting a turn-over at moderate velocity and decreasing at higher velocity. This is because, with increasing velocity, the production cross sections for Universe colorful horizons are increased; however, the thermal distribution for particles is decreased.

Keywords: Accelerated expansion, Klein-Gordon equation, binary system, multi-horizon universe.

I. Introduction

It is accepted among the current astrophysicists and cosmologists that our universe is encountering an accelerated expansion phase. This was first declared in February 1998, in light of the concordance of two group's information on SN Type Ia [1-2]. To consider the properties of accelerated expansion, one can use of an observer that accelerates due to fundamental interactions around the boundary surface of Universe. An accelerated spectator can't get to data about the entire of space- time since, from his point of view, a correspondence horizon shows up outside of boundary surface of Universe [3-6]. Fundamental interactions generate different accelerations and consequently different horizons are observed outside of Universe. As the accelerations of observer are moderately large, the horizons can be source for particle generation through Hawking radiation [7-9]. Truth be told there can be a tremendous amount of overwhelming (Higgs and Supersymmetry) molecule generation from these horizons, substantially more than anticipated from ordinary pQCD forms [10-11].

The motivation behind this paper is to compare about radiuses and cross sections of different horizons in multi-horizons Universe. We additionally discuss the generation of binary frameworks in this Universe.

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The paper is outlined as follows. In Section II, we acquire the Universe metric inside the colorful parts of expanding Universe. In Section III, we discuss the week, electromagnetism and colorful horizons with gravitational horizon. In Section IV, we compute the generation cross section for particles in binary framework inside the expanding Universe. Finally, conclusion is given.

II. Colorful horizon in multi-horizon Universe

In this section, we obtain the colorful horizon for color part of expanding Universe. For this reason, we write Klein Gordon equation for one colored particle that accelerates inside the colorful part of expanding Universe. To solve this equation, we should use of spherical coordinate [6]. For this, we represent reparameterizations and obtain Universe metric. We demonstrate that accelerated particle observes one horizon outside of boundary surface of colored part of Universe.

The Klein Gordon equation in spherical coordinate is as:

$$\{-\frac{\partial^2}{c^2\partial t^2}+\frac{\partial^2}{\partial r^2}+\frac{\partial^2}{r^2\partial\theta^2}+\frac{\partial^2}{r^2\sin^2\theta\partial\phi^2}\}\text{particle}=0 \tag{1}$$

By taking following transformations:

$$\begin{aligned} r &\to \rho_{color}(r,t) \\ t &\to \tau_{color}(r,t) \end{aligned} \tag{2}$$

The equation (1) can be written as:

$$\begin{aligned} &[\{(\frac{\partial\tau_{color}}{\partial r})^2-(\frac{\partial\tau_{color}}{\partial t})^2\}\frac{\partial^2}{c^2\partial\tau_{color}{}^2}+ \\ &\{(\frac{\partial\rho_{color}}{\partial r})^2-(\frac{\partial\rho_{color}}{\partial t})^2\}]\frac{\partial^2}{\partial\rho_{color}{}^2}+ \\ &\frac{\partial^2}{\rho_{color}^2\partial\theta^2}+\frac{\partial^2}{\rho_{color}^2\sin^2\theta\partial\phi^2}]\text{particle}=0 \end{aligned} \tag{3}$$

The boundary surface of colored part of Universe can be set at 1, by choosing following choice for r:

$$\rho_{color}(r,t) = \frac{r}{R_{color}(t)} \quad ,$$

$$\tau_{color} = \beta c^2 \int_0^t dt' \frac{R_{color}(t')}{\dot{R}_{color}(t')} - \beta \frac{r^2}{2} \tag{4}$$

where the radius of spherical frame is denoted by Rcolor(t) and β is a constant. Based on above transformations, the Klein Gordon equation is composed as:

$$(-g)^{1/2} \frac{\partial}{\partial x^{\mu}} [g^{\mu\nu} (-g)^{1/2} \frac{\partial}{\partial x^{\nu}}] \text{particle} = 0 \tag{5}$$

where $x^0 = \tau, x^1 = \rho, x^2 = \theta, x^3 = \phi$ and elements of the metric are calculated as:

$$g^{\tau\tau} = \frac{1}{\beta^2 c^2} (\frac{\dot{R}_{color}}{R_{color}})^2 (\frac{1 - \frac{\dot{R}_{color}}{c^2} \rho_{color}^2}{(1 + \frac{\dot{R}_{color}}{c^2} \rho_{color}^2)^2})$$

$$g^{\rho\rho} = -R_{color}^2 (\frac{1 - \frac{\dot{R}_{color}}{c^2} \rho_{color}^2}{(1 + \frac{\dot{R}_{color}}{c^2} \rho_{color}^2)^2})$$

$$g^{\theta\theta} = \rho_{color}^2 \quad , g^{\phi\phi} = \rho_{color}^2 \sin^2\theta \quad , g^{\tau\phi} = g^{\theta\phi} = g^{\tau\rho} = g^{\theta\rho} = g^{\phi\rho} = 0 \tag{6}$$

The colorful horizon of Universe is located at:

$$\rho_{color\, horizon} = \frac{r_{color\, horizon}}{R_{color}} = \frac{c^2}{\dot{R}_{color}^2} \tag{7}$$

This horizon is out of boundary surface of colored part of expanding Universe. Because, the velocity of the expansion is less than the velocity of light. It is concluded that $g^{\tau\tau} > 0, g^{\rho\rho} < 0$ and observer is located inside the boundary surface of colored part of Universe, however in considering black holes $g^{\tau\tau} < 0, g^{\rho\rho} > 0$ and observer is located outside the horizon.

The production cross section for colored part of expanding Universe at present stage is obtained as:

$$\sigma^{\text{expanding colorful part}} = \pi r_{colorful\, horizon}^2 = \pi \frac{c^4}{\dot{R}_{color}^4} R_{color}^2 \tag{8}$$

This cross section depends on the location of horizon and acceleration of Universe. With similar calculations, we can obtain the Universe horizon for other fundamental interactions. In following section, we compare the radius and cross section of this horizon with the radius and cross sections of other Universe horizons that are produced due to electromagnetic, weak and gravitation interactions.

III. Comparing radiuses of horizons in multi-horizon Universe

In this section, we compare the radiuses and cross sections of fundamental horizons. To compare the radiuses and cross sections of horizons, the relative strength of gravitation is regarded one. The four interactions in which the gravitation is weakest. The large-scale phenomena like the black holes, structure of galaxies and the expansion of the universe is due to the long range of gravitation. First let us to compare gravitation horizon with weak horizon.

Some nuclear phenomena like beta decay is due to the weak nuclear force or weak interaction .In the electroweak interaction theory, the gauge bosons (massive) known as the W and Z bosons are the carriers of the weak force. The relative strength of weak interaction is 1025. Thus, the weak horizon and weak cross section can be obtained as:

$$\frac{R_{weak}}{R_{gravitation}} \propto 10^{25}, \frac{\dot{R}^2_{weak}}{\dot{R}^2_{gravitation}} \propto 10^{50}$$
$$\rightarrow r_{weak\,horizon} = 10^{-25} r_{\mathrm{gravitational}\,horizon}$$
$$\rightarrow \sigma^{\text{expanding weak part}} = 10^{-50} \sigma^{\text{expanding gravitational part}} \tag{9}$$

Therefore, the radius of weak horizon is smaller than the radius of gravitation horizon. Also, the production cross section for weak horizon is smaller than gravitation horizon.

Electromagnetism is another basic force that works between particles (electrically charged). At rest, this wonder incorporates the electrostatic force acting between charged particles and the joint impact of magnetic and electric forces acting between charged particles moving with respect to each other. The relative strength of electromagnetism interaction is 1036. Thus,the electromagnetism horizon and electromagnetism cross section can be obtained as:

$$\frac{R_{\mathrm{Electromagnetism}}}{R_{gravitation}} \propto 10^{36}, \frac{\dot{R}^2_{\mathrm{Electromagnetism}}}{\dot{R}^2_{gravitation}} \propto 10^{72}$$
$$\rightarrow r_{\mathrm{Electromagnetism}\,horizon} = 10^{-36} r_{\mathrm{gravitational}\,horizon}$$
$$\rightarrow \sigma^{\text{expanding Electromagnetism part}} = 10^{-72} \sigma^{\text{expanding gravitational part}} \tag{10}$$

Therefore, the radius and cross section of electromagnetism horizon is smaller than the radius of gravitation horizon.

Finally, the strong interaction is the most complicated interaction, that is explained by QCD "Quantum Choromo Dynamics". QCD is a hypothesis of partially colored quarks communicating by means of 8 colored photon-like particles called gluons. The gluons communicate with each other, not simply with the colored quarks, and at long separations, the lines of force collimate into strings. Thus, the color horizon and electromagnetism cross section can be calculated as:

$$\frac{R_{\text{color}}}{R_{gravitation}} \propto 10^{38}, \frac{\dot{R}^2_{\text{color}}}{\dot{R}^2_{gravitation}} \propto 10^{76}$$
$$\to r_{\text{colorful}\,horizon} = 10^{-38} r_{\text{gravitational}\,horizon}$$
$$\to \sigma^{\text{expanding colorful part}} = 10^{-76} \sigma^{\text{expanding gravitational part}} \quad (11)$$

Thus, the radius and cross section of gravitation horizon is more than other fundamental interactions. This means that gravitation interaction depends on the larger scale structure of the universe respect to other interactions.

IV. Binary systems inside the multi-horizon Universe

The action of confining Color may produce a snare between colorful parts of Universe to shape color singlet binary framework inside the electromagnetism horizon. The investigation of colored particles inside the snared parts first comprises of copying the degrees of freedom of the system. At this end a duplicate of the Hilbert space of inside the colorful horizon might be built by a set of operators of creation/annihilation that have an indistinguishable replacement property from the first ones. The tensor product of the two spaces is the total Hilbert spaces, where this tensor signifies the physical quantum states space of the particles in part 1 and part 2. The particle lying in part 2 influences the particle state inside the part 2 by entrapment. Along these lines, in concurrence with [12, 13] we can compose the Bogoliubov transformations between the creation and annihilation operators of Minkowski Universes and extending Universes:

$$(\alpha_{1,color} - \tanh r_\omega \alpha_{2,anticolor})\left|\text{expanding Universe}\right\rangle_{1\otimes 2} = 0$$
$$\tanh r_\omega = e^{-2\pi\omega} \quad (12)$$

Now, we suppose that the Kruskal vacuum $\left|\text{expanding Universe}\right\rangle_{in\otimes out}$, is connected to the flat vacuum $\left|0\right\rangle_S$ by:

$$\left|\text{expanding Universe}\right\rangle_{1\otimes 2} = F(\alpha_{1,color}, \alpha_{2,anticolor})\left|0\right\rangle_S \quad (13)$$

where F is some mapping to be resolved later.

From $[\alpha_{1,color}, \alpha^\dagger_{1,color}] = 1$,we obtain $[\alpha_{1,color}, (\alpha^\dagger_{1,color})^m] = \frac{\partial}{\partial \alpha^\dagger_{1,color}}(\alpha^\dagger_{1,color})^m$ and $[\alpha_{1,color}, F] = \frac{\partial F}{\partial \alpha^\dagger_{1,color}}$. Then using equations (12) and (13), we obtain the differential equation for F as follows:

$$(\frac{\partial}{\alpha_{1,color}^{\dagger}} - \tanh r_{\omega}\alpha_{2,anticolor})F = 0 \tag{14}$$

and the solution is given by

$$F = e^{\tanh r_{\omega}\alpha_{1,color}^{\dagger}\alpha_{2,anticolor}^{\dagger}} \tag{15}$$

By putting (15) into (13) and by legitimately normalizing the state vector, we obtain:

$$\left|\text{expanding Universe}\right\rangle_{1\otimes 2} = e^{\tanh r_{\omega}\alpha_{1,color}^{\dagger}\alpha_{2,anticolor}^{\dagger}}\left|0\right\rangle_{S} = \frac{1}{\cosh\ r_{\omega}}\sum_{n}\tanh^{n} r_{\omega}\left|n\right\rangle_{1}\otimes\left|\tilde{n}\right\rangle_{2} \tag{16}$$

where $\left|n\right\rangle_{1},\left|\tilde{n}\right\rangle_{2}$ are (normal mode solutions) orthonormal bases for H_1 and H_2 respectively.We see that the ground state for particles near colorful horizonsis a maximally ensnared with two-mode crushed states on part1 and part2 Hilbert spaces of expanding Universe. We obtain the thermal distribution for entangled particles between colored parts as the following:

$$\begin{aligned}N_{\omega} &= {}_{1\otimes 2}\left\langle\text{expanding Universe}\right|\alpha_{1,color}^{\dagger}\alpha_{1,color}\left|\text{expanding Universe}\right\rangle_{1\otimes 2} \\ &= {}_{2}\left\langle n\right|{}_{1}\left\langle n\right|\frac{1}{\cosh^{2} r_{\omega}}\alpha_{1,color}^{\dagger}\alpha_{1,color}\sum_{n=0}^{\infty}\tanh^{2n}(r_{\omega})\left|n\right\rangle_{1}\left|n\right\rangle_{2} \\ &= {}_{2}\left\langle n\right|{}_{1}\left\langle n-1\right|\frac{1}{\cosh^{2} r_{\omega}}\sum_{n=0}^{\infty}\tanh^{2n}(r_{\omega})(n)\left|n-1\right\rangle_{1}\left|n\right\rangle_{2} \\ &= \frac{1}{\cosh^{2} r_{\omega}}\sum_{n=0}^{\omega}e^{-4\pi n\omega}(n) = \frac{1}{\cosh^{2} r_{\omega}}\frac{e^{-4\pi\omega}}{(1-e^{-4\pi\omega})^{2}} = \frac{e^{-4\pi\omega}}{(1-e^{-4\pi\omega})}\end{aligned} \tag{17}$$

Equations (16,17) represent that various number of entangled particles observed with different probabilities on the parts 1 and 2of expanding Universe. These probabilities are connected to horizon and the energy of particles.

$$P_{n,\omega} \approx \left|{}_{out}\left\langle n\right|\otimes{}_{in}\left\langle n\right|\exp anding\ frame\right\rangle_{in\otimes out}\Big|^{2} = \frac{e^{-4\pi n\omega}}{\cosh^{2} r_{\omega}}.$$

It seems that many particles produce near event horizon due to variety in their energy and their probabilities.

To obtain the total production cross section for entangled parts, we have to duplicate the colored part creation cross section by the thermal distribution for particles in trapped parts.

$$\sigma^{particles} = \int_{0}^{M_{\text{expanding colorful part1}}} d\omega N_{\omega}\sigma^{\text{expanding colorful part1}}\sigma^{\text{expanding colorful part2}} \tag{18}$$

where we have used of this fact that:

$$M_{\text{expanding colorful part1}} = \frac{3\pi}{4\Gamma(\frac{3}{2})G} r^2_{colorful\ horizon} \tag{19}$$

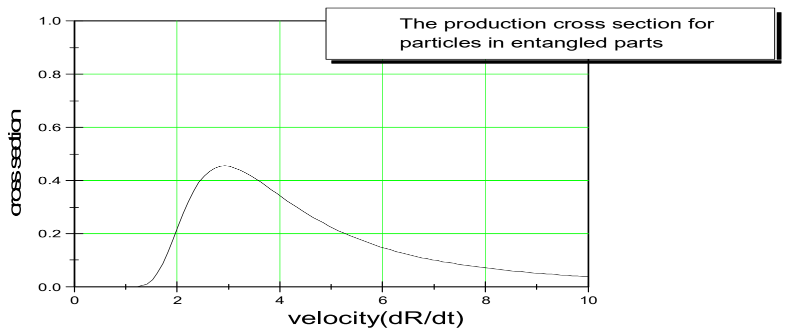

Fig.1: The cross section production for particles in binary system as a function of $\dot{R}$.

We have given the outcomes for the cross sections of particles delivered in snared parts as a component of $\dot{R}$ in Fig.1. We choose in this graph $R_2 = R_1 = 10^{18}\dot{R}_1 = 10^{18}\dot{R}_2$ for the radius of Universe colorful parts. As can be seen from the figure, the cross section is rising at lower frame velocity, exhibiting a turn-over at moderate velocity and decreasing at higher velocity. This is because, with increasing $\dot{R}$, the production cross section for horizon is increased; however, the thermal distribution for particles is decreased.

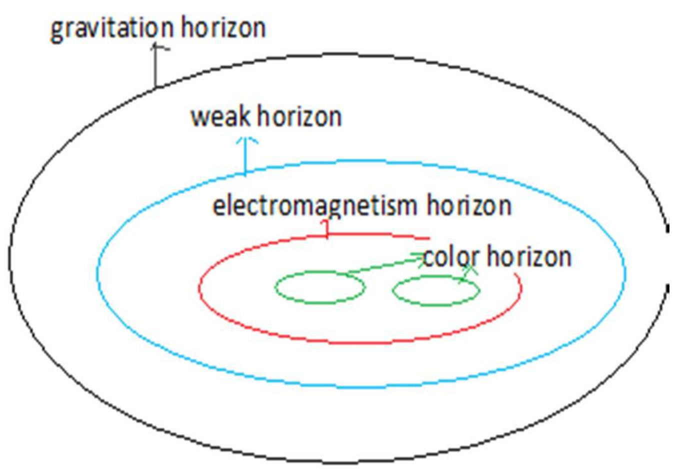

Fig.2: The binary system in multi-horizon Universe.

In Fig.2, we present binary system inside the multi-horizon Universe. The green curves are corresponded to colorful–anti-colorful parts of Universe. These parts should be entangled to form one singlet color system. Also, maybe three colorful or anti-colorful parts generate singlet system. Thus Universe can have more than two colorful parts inside the electromagnetism horizon. Finally, outside this horizon, there isn't any colored particle.

V. Conclusion

In this present research, we show that fundamental interactions generate multi-horizon Universe. Using the spherical coordinates and assuming acceleration in r direction, we obtain the Universe metric. Consequently, by considering this metric we derive the radiuses and cross sections of different horizons. Comparing these horizons with each other, we observe that the radius and cross section of gravitational horizon is more and the radius and cross section of color horizon is less than other horizons. Finally, we find that Color confinement may generate an entanglement between colorful parts of Universe to form color singlet binary system inside the electromagnetism horizon. The cross section for particles inside this system is rising at lower expansion velocity of Universe colorful part, exhibiting a turn-over at moderate velocity and decreasing at higher velocity. This is because, with increasing velocity, the production cross sections for Universe colorful horizons are increased; however, the thermal distribution for particles is decreased.

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References

[1] S. Perlmutter et al., Nature 391, 51 (1998).
[2] A. G. Reiss et al., Supernova SerachTeam,Astron. J. 116, 1009 (1998). astro-ph/9805201.
[3] Luis C.Barbado, MttVisser, Physical Review D 86 (2012) 084011.
[4] Robert Beig, J. Mark Heinzle, Am. J. Phys 76 663 (2008).
[5] CharisAnastopolous, NtinaSavvidou, J. Math. 53, 012107 (2012).
[6] Christian Corda, Herman J. Mosquera Cuesta, Euro. Phys.Lett 86 20004, 2009.
[7] A.Sepehri, S.Shoorvazi, AstrophysSci (2013a)doi 10.1007/s10509-012-1350-9.
[8] A. Sephari, M. E.Zomorrodian, A.MoradiMarjeneh, P.Eslami, S. Shoorvazi Can. J. Phys 90, 25-37 (2012).
[9] A.Sepehri, S.Shoorvazi, S. J. Fatemi, S. Doostmohammadi, Astrophys. Space Sci. (2012a) doi 10.1007/s10509-012-1321-1.
[10] NikolaosKidonakis, Phys. Rev. D77:053008, (2008)
[11] MaihiasButenschoen, Frank Fugel Bernd A.Kniehl, Phys. Rev.Lett. 98:071602 (2007).
[12] DoyeolAhn, Phys. Rev. D74:084010,(2006) (1976)
[13] D. Ahn, Y. H. Moon, R. B. Mann, I., Fuentes-Schuller, JHEP0806:062,(2008).