Proof of No Singularity in Schwarzschild Black Hole and Big Bang

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In this paper, we propose that the center of Schwarzschild black hole (SBH) and the Big Bang are in the minimum entropy equal to the Boltzmann constant. Then we prove the uncertainty relation (UR) of SBH and Big Bang UR which suggest no singularity in SBH and Big Bang.

Ⅰ. Introduction

S.W. Hawking and R. Penrose proved the theory of singularities [1]. It shows that the singularities are in the black holes and the universe originated the Big Bang singularity. Many literatures discussed no singularity in black holes and Big Bang with the quantum effect; please refer to [2]. Moreover, M. Planck considered the reduced Planck constant ħ being the minimum action [3]. R. Penrose considered the Big Bang being in the minimum entropy equal to zero [4]. It is the initial condition of Big Bang probably. Similarly we propose the center of Schwarzschild black hole (SBH) and Big Bang being in the minimum entropy, but the minimum entropy doesn't equal to zero. Then we can prove the uncertainty relation (UR) of SBH and Big Bang UR which proposed by Y. Bao [5].

This paper is organized as follows. In Sec. II, we prove the UR of SBH. In Sec. III, we prove the Big Bang UR. We conclude in Sec. IV.

Ⅱ. No singularity in SBH

Y. Bao proposed the UR of SBH by the generalized relation [5].

$$M_H V_H \sim \mathrm{M_P V_P} = \mathrm{M_P L_P^3} = \hbar^2 \mathrm{G} / \mathrm{c}^4 \qquad (1)$$

where G, c, M_H, V_H, $\mathrm{M_P} = \sqrt{\hbar c/G}$, $\mathrm{V_P} = \mathrm{L_P^3}$ and $\mathrm{L_P} = \sqrt{\hbar G/c^3}$ denote the gravitational constant, speed of light in vacuum, SBH mass, volume of SBH center, Planck mass, Planck volume and Planck length, respectively. It is impossible to measure the SBH mass and volume simultaneously. Therefore it suggests no singularity in SBH with quantum effect.

We prove (1) now. For the Coulomb-like gravitational fields, from $s_{grav} = 2\alpha\pi\kappa^2 c^2 T_{grav} / \hbar^2 G$ [6] and $S_{grav} = \int_V s_{grav}$ [7], we obtain

$$S_{grav} = 2\alpha\pi\kappa^2 c^2 T_H V_H / \hbar^2 G \qquad (2)$$

where s_{grav} is the entropic density, α a constant, T_{grav} the effective temperature, S_{grav} the entropy of SBH center, and V the spatial volume. For the SBH center, $V \rightarrow V_H$ and $T_{grav} \rightarrow T_H$, where T_H is the temperature of center.

We assume $S_{grav} \sim \kappa$ that is the Boltzmann constant κ being the minimum entropy, resembling ħ. Then we find

$$T_H V_H \sim \hbar^2 G / 2\alpha\pi\kappa c^2 \qquad (3)$$

Therefore the temperature of SBH center and its volume have the inversely-proportional relationship.

From the gravitational analogue of the fundamental law of thermodynamics in the form [7]

$$T_{grav}\, dS_{grav} = dU_{grav} + p_{grav} dV \qquad (4)$$

where U_{grav} and p_{grav} denote the internal energy and isotropic pressure of the free gravitational field, respectively. Taking (3), $p_{grav} = 0$ [7], and $dU_{grav} \approx d(M_H c^2)$ to (4), we give

$$M_H V_H \sim \hbar^2 G / 2\alpha\pi c^4 \qquad (5)$$

Similarly for the wave-like gravitational fields, $p_{grav} = \rho_{grav} / 3$ [7], we obtain

$$M_H V_H \sim 3\hbar^2 G / 8\sqrt{6}\beta\pi c^4 \qquad (6)$$

where β is a constant. Then we prove (1).

III. No singularity at Big Bang

The Big Bang UR is [5]

$$T_B V_B \sim \hbar^2 G / \kappa c^2 \qquad (7)$$

where V_B is the volume of Big Bang and T_B its temperature. It suggests no singularity at Big Bang with quantum effect also.

For a spatially flat Robertson–Walker geometry with scalar perturbations in a longitudinal gauge, such that the line-element can be written [7] (ħ = G = c = κ = 1)

$$ds^2 = a^2(\tau)[-(1+2\Phi)d\tau^2 + (1-2\Phi)(dx^2 + dy^2 + dz^2] \qquad (8)$$

$$u^a = [(1-\Phi)/a;\ u^i],\ z^a = (0;\ \nabla_i\Phi)/a\,|\nabla\Phi| \qquad (9)$$

$$S_{grav} \sim t^{5/3} \qquad (10)$$

where a is the scale factor, u^a the timelike unit vector, z^a a spacelike unit vector, and $t = \int a(\tau) d\tau$ the proper time of comoving observers.

When $t \rightarrow 0$, $S_{grav} \rightarrow 0$, so R. Penrose considered the Big Bang being in the minimum entropy equal to zero [4]. But we propose

$$S_{grav} \sim t^{5/3} + S_{grav0} \qquad (11)$$

where $S_{grav\,0} \geq 0$ is the minimum entropy. When $t \to 0$, $S_{grav} \to S_{grav\,0}$, $V \to V_B$, and $T_{grav} \to T_B$, Substituting them, dU_{grav} = d($\rho_{grav}V$), and $p = \omega\, \rho_{grav}$ into (4), we obtain

$$T_B \mathrm{d}S_{grav\,0} \sim V_B \mathrm{d}\rho_{grav} + (1+\omega)\, \rho_{grav} \mathrm{d}V_B \quad (12)$$

where ω is the coefficient of state.

From [7] (ħ = G = c = κ = 1)

$$8\pi\rho_{grav} = \alpha\,|\,(a^4 \dot{u}_{<i,j>})z^i z^j\,|\ /\ a^3 \quad (13)$$

$$T_{grav} = \ |\,H\,|\ /\ 2\pi \quad (14)$$

where i, j are spatial indices, we gain

$$\rho_{grav} \sim \kappa^2 c^2 T_{grav}^2\ /\ \hbar^2 G \quad (15)$$

Taking (15) to (12), we give

$$\mathrm{d}S_{grav\,0} \sim \kappa^2 c^2 [2V_B \mathrm{d}T_B + (1+\omega) T_B \mathrm{d}V_B\,]\ /\ \hbar^2 G \quad (16)$$

Also assuming $S_{grav\,0} \sim \kappa$ that is Big Bang being in the minimum entropy equal to Boltzmann constant, and ordering $\omega = -1$, we find

$$T_B V_B \sim \hbar^2 G\ /\ 2\kappa c^2 \quad (17)$$

Hence we prove (7). Note (3) and (17), they are analogous, but their physical meaning aren't same.

IV. Conclusion

In this paper, we assumed the center of SBH being in the minimum entropy equal to the Boltzmann constant κ, found the temperature of center and its volume having the inversely-proportional relationship; proved the UR of SBH which suggests no singularity in it, whether the gravitational fields are Coulomb-like or wave-like; proposed the Big Bang being in the minimum entropy equal to κ also, proved the Big Bang UR suggesting no singularity.

From the original definition of entropy $S = Q\ /\ T$, for the Big Bang, the heat quantity Q is tremendous but finite, if $S \to 0$, the temperature $T \to \infty$, that is infinite. This is the classical solution. Considering the quantum effect, T is impossibly infinite, so $S \neq 0$. Then we proposed the Big Bang being in the minimum entropy equal to κ. Similarity for the center of SBH, $Q \approx M_H c^2$, the temperature of center isn't infinite with quantum effect. Note here we only consider the center of SBH, not the total SBH, it isn't against principle of entropy increase of black holes.

References

[1] S.W. Hawking and R. Penrose, *Proc. Roy. Soc. London*. A **314** (1970), 529, 48; S.W. Hawking, F.R. Ellis, The large scale structure of space-time, Cambridge University Press, 1973; J.K. Beem, and P.E. Ehrlich, Global Lorentzian Geometry, Marcel Dekker, New York, 1981.

[2] Z-Y. Shen, *Journal of Modern Physics*, **4** (2013), 1213-1380; E. Buckingham, *Physical Review*, 1914, 4(5): 345-376; P.W. Bridgman, Dimensional Analysis, New Haven: Yale University Press, 1922; Chien Wei-Zang, Applied Mathematics, Anhui Science and Technology Press, 1993, P. 154; S.W. Hawking and R. Penrose, *Proc. Roy. Soc. London*. A **314** (1970), 529, 48; S.W. Hawking, F.R. Ellis, The large scale structure of space-time, Cambridge University Press, 1973; J.K. Beem, and P.E. Ehrlich, Global Lorentzian Geometry, Marcel Dekker, New York, 1981; M.B. Green, J.H. Schwarz and E. Witten, Superstring Theory, Cambridge University Press, 1987; M. B. Green, J. H. Schwarz and E. Witten, Superstring Theory, Vol. I and Vol. II, Cambridge University Press, 1988; J. Polchinski, String Theory, Vol. I and Vol. II, Cambridge University Press (1998); K. Becker, M. Becker and J. H. Schwarz, String Theory and M-Theory: A Modern Introduction, Cambridge University Press, 2007; M. Bojowald, *Phys. Rev. Lett.* **86** (2001), 5227-5230; H. Viqar, W. Oliver, *Phys. Rev*. D **69** (2004), 084016; L. Modesto, *Phys. Rev*. D **70** (2004), 124009; LI ChangZhou, YU Guoxiang, XIE ZhiFang, *Acta. Physica. Sinica*., 59, **3** (2010); Y.J. Wang, Black Hole Physics, ChangSha: HuNan Normal University Press, 2000.4; A.F. Ali, S. Das, *Phys. Lett.* B **741** (2015) 276-279.

[3] M. Planck, *physikalische Abhandlungen und Vortäge*. Braunschweig, 1958.

[4] R. Penrose, *Cycles of Time: An Extraordinary New View of the Universe*, Knopf, USA, 2011.

[5] Y. Bao, viXra: 1502.0101.

[6] Y. Bao, viXra: 1409.0159.

[7] T. Clifton, G. F. R. Ellis and R. Tavakol, Class. Quantum Grav.**30** (2013) 125009 (15pp).