Black Hole Universe – A Complete Structure of the Entire Spacetime

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A complete hierarchically layered structure of the entire spacetime is established in accordance with the black hole universe model that the author comprehensively developed on the basis of the three fundamentals without any other hypothetical entities: (1) Newton's cosmological principle (CP) of spacetime homogeneity and isotropy in a large scale, (2) Einstein's general theory of relativity (GR) that describes the effect of matter on spacetime, and (3) Zhang's principle of spacetime black hole equivalence (SBHEP) that postulates spacetimes and black holes to be equivalent (i.e. a black hole wraps a spacetime and a spacetime encloses a black hole). This alternative cosmological model not only explains all the observations of the universe without relying on any other hypothetical entities, but also overcomes all the cosmic difficulties based on the well-developed physics. Our universe is a black hole or spacetime and the observed starlike, massive, and/or supermassive black holes are child universes or subspacetimes of our black hole universe. The author's previous studies have fully and self-consistently described and explained various aspects of black hole universe such as its origin, structure, expansion, evolution, acceleration, emission, entropy, cosmic microwave background radiation, and so on. This study, by constructing the inside of the child universes of our black hole universe, to further develop a complete structure of the entire spacetime and provide us a complete new view to the inside of a black hole and a unique solution of the spacetime singularity.

1 Introduction

A physical cosmology is a branch of study in physics and astrophysics for the physical origin and evolution of the universe. A successful cosmological model should be simple, significant, and complete. Simplicity of a cosmological model refers to that the model is straight-forward and can simply and fully describe the universe based on the currently well-developed laws and theories of physics and astrophysics without making hypotheses that not only are non-testable but also violate the laws of physics and astrophysics. Significance of a cosmological model refers to that the model is important and can significantly explain all the observations of the universe and overcome all the cosmic problems without having any difficulty or without relying on any hypothetical entities. Completeness of a cosmological model refers to that the model is in its totality/entirety and can completely interpret the origin and evolution of development of the entire spacetime rather than only a finite part of the infinite universe or spacetime.

The standard big bang model of the universe (BBU) was developed on the two solid bases: (1) Einstein's general relativity (GR) that describes the effect of matter on spacetime [1] and (2) Newton's cosmological principle (CP) of spacetime isotropy and homogeneity. The Einsteinian field equation given in GR along with the Friedmann-Lemaitre-Robertson-Walker (FLRW) metric of spacetime derived from CP leads to the Friedmann equation (FE) that governs the development and dynamics of the universe [2]. The big bang theory has made incredible successes in explaining the universe, but there exist innumerable problems and difficulties. Solutions of these problems and difficulties severely rely on an increasing number of hypothetical entities (HEs) such as dark matter, dark energy, inflation, big bang singularity, and so on [3]. Therefore, BBU consists of GR, CP, and innumerable HEs, i.e. BBU = {GR, CP, HE, HE, HE,....} (see the blue part of Figure 1). Although it has only two bases (GR and CP), the BBU is neither simple and significant because of severely relying on an increasing number of HEs, which have not yet been and may never be tested or falsified, nor complete because of being finite and thus having unknown (or unable to answer) outside and prehistory.

Recently, the author has developed a new physical cosmology called black hole universe (BHU) [4-5]. Instead of making many HEs as the BBU did, the BHU proposes a new principle to the cosmology - the Principle of Spacetime Black Hole Equivalence (SBHEP) [6] - in an attempt to explain all the existing observations of the universe and overcome all the existing problems and difficulties. Standing on the three bases (GR, CP, and SBHEP), this new cosmological theory - BHU = {GR, CP, SBHEP} (see the red part of Figure 1) - can fully explain the universe in various aspects as well as to conquer all the cosmic problems according to the well-developed physics neither making any other HEs nor including any other unsolved difficulties [7-12]. GR and CP are common to both BBU and BHU. The BBU stands on two legs unstably so that it needs many crutches (or HEs) for support, while the BHU stands on three legs stably without needing any other props. In the BHU, a single SBHEP simply removes all of those innumerable HEs made in the BBU.

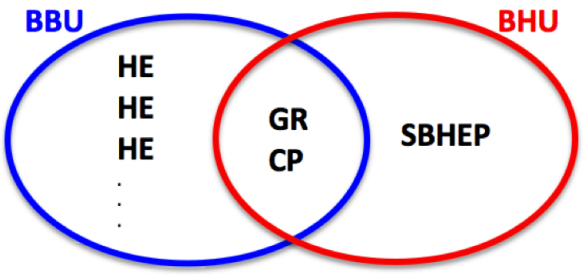

Fig. 1: The BBU versus the BHU [6, 12]. The BBU is developed on the basis of GR and CP with innumerable HEs to explain observations and overcome cosmic problems and difficulties. The BHU is developed on the basis of GR, CP and SBHEP. With one more base, SBHEP, the BHU can also perfectly explain all the existing observations of the universe and meantime overcome the cosmic problems and difficulties in terms of the well-developed physics without needing any other HEs.

The BHU is simple and significant because it does not rely on any HEs, but can fully explain the observations of the universe and overcome the cosmic problems and difficulties in terms of well-developed physics. It is also complete because the entire spacetime is infinite without unknown outside and prehistory. In the previous studies, the author has comprehensively explained various aspects of the universe, including its origin, structure, evolution, expansion, acceleration, cosmic microwave background (CMB) radiation, entropy, emissions of dynamic starlike, massive, and supermassive black holes such as gamma ray bursts, X-ray flares from galactic centers, and quasars, and so on [5-12]. However, the structure of the entire spacetime previously developed was only down to the level of the child universes of our black hole universe, i.e. the observed starlike, massive, and/or supermassive black holes. This study extends the structure of the entire spacetime into the deep insides of the child universes. This effort will provide us a complete structure of the entire spacetime and meantime shows us a brand new view to the insides of black holes, which may solve the black hole singularity issue.

2 Complete structure of the entire spacetime

According to the black hole model of the universe, our four-dimensional (4D) spacetime universe is a black hole, which is an extremely suppermassive and has been fully expanded with mass about a half hundred sextillions of solar masses, radius about forty-three hundred Mpc (or one Hubble length), and surface gravitational field about one third nanometer per second square [5-6]. All the inside, currently observed, starlike, massive, and/or supermassive black holes are subspacetimes (or child universes) of our black hole universe. Figure 2 shows the two-level or layer structure of any sized black hole or spacetime, including our black hole universe, and its child black holes. A black hole is a spacetime and its child black holes are its subspacetimes. For our black hole universe, the child universes or subspacetimes are the observed starlike, massive, and/or supermassive black holes. This hierarchically layered structure of spacetimes and subspacetimes genuinely overcomes the horizon problem, which was identified to exist in the big bang model of the universe primarily by Charles Misner in 1960s [13] and solved by Alan Guth in 1980s with the hypothesis of cosmic inflation [14] according to a field that does not correspond to any physical field. Therefore, in the black hole model of the universe, there does not exist the horizon problem at all. The scale of a black hole or spacetime should be much larger than that of its child black holes or subspacetimes.

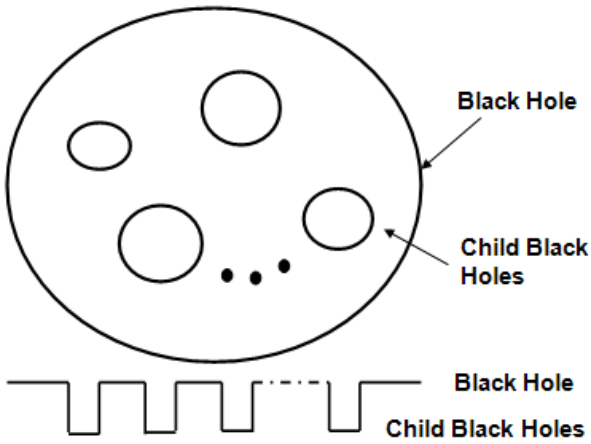

Fig. 2: The two-level or layer structure of a black hole or spacetime. Inside a black hole or spacetime, there are a number of child black holes or subspacetimes. For an example, inside our black hole universe, there are a number of child black hole universes or subspacetimes, which are the observed starlike, massive, and/or supermassive black holes.

Inside a black hole or spacetime, there are a number of child black holes or subspacetimes rather than singularity at the center as described conventionally. Outside a black hole or spacetime, there are a number of parallel sister black holes or spacetimes. Figure 3 shows a three-level or layer structure of a black hole or spacetime with both its inside and outside. The black hole or spacetime and all the parallel sister black holes or spacetimes are child black holes or subspacetimes of the mother black hole. Here, for the sketch to be simple, we have only drawn, inside each black hole or spacetime, three child black holes or subspacetimes. For our black hole universe, the observed starlike, massive, and/or supermassive black holes are its child universes or subspacetimes. The outside parallel universes are its sister universes. Our black hole universe and all the parallel sister universes are child universes or subspacetimes of the mother universe. Figure 4 sketches the four layers of the black hole universe from the child universe up to the grandmother universe which contains the aunt universes, mother universe, sister universes, cousin universes, our universe itself, child universes, and niece uni-

verses. Here again for the sketch to be simple, we only drew three universes for each layer. If the whole space is finite, then the matter in the whole space is finite and thus the number of layers is finite. Otherwise, it has infinite layers and the outermost layer corresponds to the limit of zero degree for the absolute temperature, zero for the density, and infinity for the radius and mass. A complete cosmological model suggests that the entire universe or spacetime must be infinite. For the black hole universe model to appropriately explain CMB, we favored and suggested that the entire spacetime to be infinite and eternal and include infinite universes, which are layered hierarchically [7].

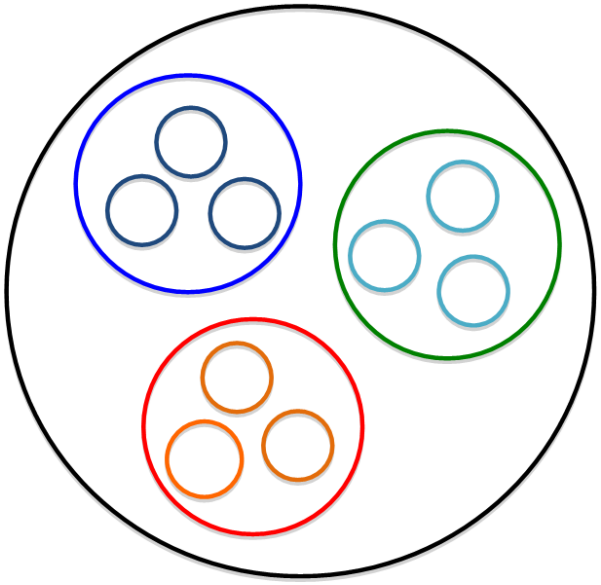

Fig. 3: The three-level or layer structure of a black hole or spacetime. Inside a black hole or spacetime (e.g. the one coded as green), there are a number of child black holes or subspacetimes. Outside the black hole or spacetime, there are a number of sister black holes (e.g., the ones coded as blue and red, respectively). Inside each of sister black holes, there are also a number of its child black holes. The black hole and all sister black holes are all the child black holes or subspacetimes of the mother black hole (coded as black). For our black hole universe, its inside has a number of the child black hole universes or subspacetimes, which are the observed starlike, massive, and/or supermassive black holes. Its outside has a number of sister black hole universes. Our black hole universe and all sister black hole universes are child black hole universes of the mother black hole universe.

For the infinite entire spacetime (called the grand universe), it has infinite layers [5-6, 12]. Figure 5 shows the infinite hierarchically layered structure of the infinite entire spacetime. The top layer is the entire spacetime, i.e. the grand universe, whose mass (M), radius (R), and entropy (S) are infinitely large; while the density (ρ) and temperature (T) (hence pressure) are infinitely small. The bottom layer is the layer of child universes, which are finite, referring to the

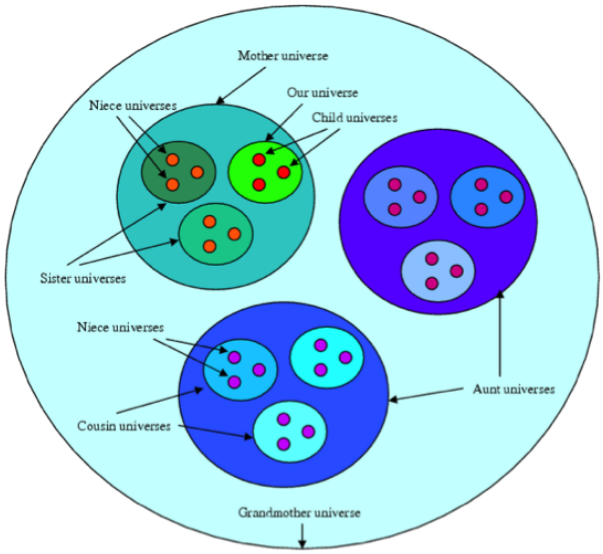

Fig. 4: The four-level or layer structure of our black hole universe up to the grandmother universe [5]. Inside our universe, there are a number of child universes, which are the observed starlike, massive, and/or supermassive black holes. Outside our universe, there are a number of sister universes who also have their own child universes named as niece universes. Our universe and all sister universes are child universes or subspacetimes of the mother universes. Parallel to the mother universe, there are a number of aunt universes who also have their child and grandchild universes or subspacetimes. The mother universe and all aunt universes are child universes or subspacetimes of the grandmother universe.

observed starlike, massive, and/or supermassive black holes. The second layer from the bottom is our universe. The child universe is a subspacetime of our universe; our universe is a subspacetime of the mother universe; the mother universe is a subspacetime of the grandmother universe, and so on. This infinitely layered structure of the entire spacetime can also be represented by using the mathematical set concepts as U = {...{F, F, F, ...{G, G, G, ...{A, A, A, ...{S, S, S, ...{C, C, C, ..., C}}}}...}. Here the child universes (also the niece universes) are null sets (i.e. C = { } and N = { }); the sister universes are sets of niece universes, S = {N, N, N, ...N}; our universe is a set of child universes, O = {C, C, C, ..., C}; the mother universe is the set of our universe and sister universes, M = {S, S, S, ..., O}; the aunt universes are sets of cousin universes, A = {Co, Co, Co, ..., Co}; the grandmother universe is the set of aunt universes and the mother universe, G = {A, A, A, ..., M}; and so on. The grand universe or the entire spacetime U is the grand set of all universes.

This previously developed infinitely layered structure of the infinite entire universe may not be complete, since it does not give what there are inside the child black hole universes. The structure of the entire universe shown in Figure 5 is only from the grand universe down to the child universes, which are currently observed starlike, massive, and/or supermassive

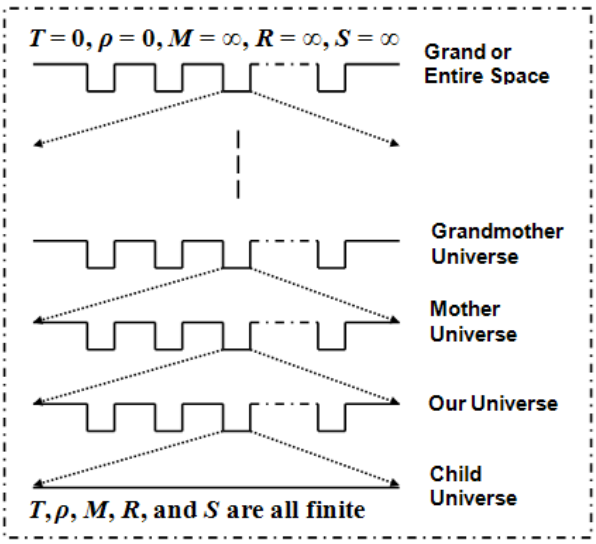

Fig. 5: The hierarchically layered structure of the entire universe, previously developed [6, 12]. It is incomplete because the bottom layer is only down to the child universes, suggested to be empty spacetimes or null sets. The child universes are subspacetimes of the universe in which we live in. Similarly, our universe is a subspacetime of the mother universe, and so on. The top or outmost layer is the entire space of all subspacetimes.

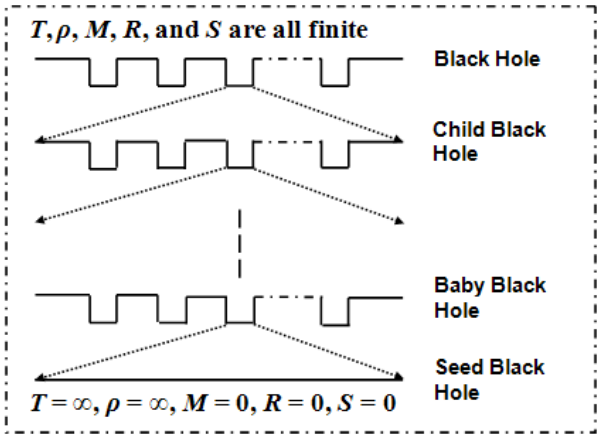

Fig. 6: The hierarchically layered structure of black holes or child black hole universes. Inside any sized black hole or spacetime, which is homogeneous and isotropic in the large or spacetime scale according to Newton's cosmological principle, there are a number of child black holes or subspacetimes. Inside a child black hole, there are a number of grandchild black holes, and so on in analogy. The bottommost is the seed black holes, which are infinitely small and are child black holes or subspacetime of a baby black holes.

blackholes. To have a complete structure of the entire spacetime, we need construct the inside of the child universes. According to Figure 2, any sized black hole or spacetime has a number of its child black holes or subspacetimes, like our black hole universe that has a great number of starlike, massive, and/or supermassive black holes as the child black hole universes. Therefore, inside a starlike, massive, or supermassive black hole, there may be in general a number of child black holes; inside a child black hole, there may be a number of grandchild black holes, and so on (see Figure 6). The innermost or bottommost layer is called seed black holes, which are infinitely small in size, mass, and entropy, but have infinitely large density, temperature, and pressure. The seed black holes are the child black holes of a baby black hole. This infinitely layered structure for the inside of a black hole or a spacetime can also be represented by using the mathematical set concepts. A black hole is a set of child black holes; a child black hole is a set of grandchild black holes, and so on in analogy. The baby black hole is a set of seed black holes, which are represented as null sets. A seed black hole has infinitely small mass, radius, and entropy, but infinitely large density, temperature, and pressure.

This hierarchically layered structure of a black hole provides us a completely new view to the inside of a black hole. At present, on what the inside of a black hole is, it is still an unsolved big open mysterious question in physics, since the Einsteinian general relativity is failed to be applicable to describe the inside of a black hole. Conventionally, most of scientists believe that matter once falling into a black hole will be gravitationally collapsed or drawn to the center point and form a dreaded singularity, where the known laws of physics break down and thus the picture of a black hole inside can be no longer trusted. As the matter inside a black hole is all drawn to the singular point at the center, there should be no matter and hence empty within the event horizon, except for the singular point at the center, which contains all matter of the black hole and thus has infinite density and temperature (see Figure 7). The matter density may be represented as the delta function of the radial distance. A recent notable study suggests that black hole are holograms [15]. This black hole holographic hypothesis considers a black hole as a holographic projection from a flat system of quantum particles that remains gravity-free. Though it may solve the clash between general relativity and quantum mechanics, the hologram model of black hole is still not fully understood. According to the black hole universe model, spacetime and black hole are equivalent. Our universe is a black hole and the observed starlike, massive, and/or supermassive black holes are subspacetimes of our 4D spacetime universe. The Einsteinian general relativity, a theory that describes the effect of matter on spacetime, is applicable to also describe the matter effect on a subspacetime, i.e. the inside of a black hole. The matter inside a black hole does not fall into the center point to form a singular point, but may form a number of child black holes or subspacetimes, which have scales much smaller than the black hole. The infinitely layered structure of a black hole as shown in Figure 6 shows the inside of a black hole to be infinite asymptotically singular spacetmes.

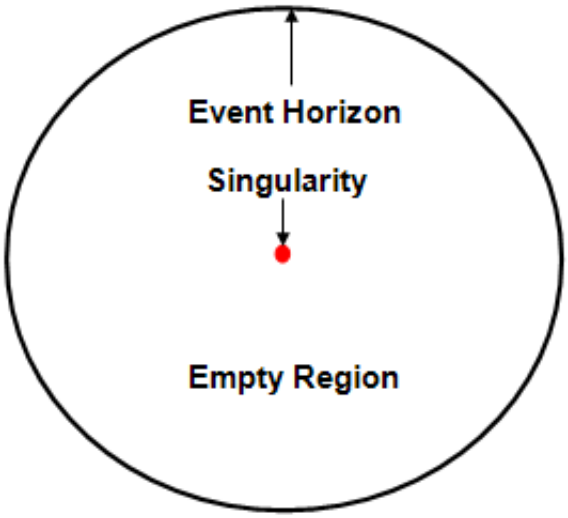

Fig. 7: The singularity of black hole. Conventionally, the matter falling into a black hole will be gravitationally collapsed or drawn to the center point and form a dreaded singularity, where the matter density goes to infinity. This will leads to the most interior region of a black hole does not have matter or is an empty space.

Considering the starlike, massive, and/or supermassive black holes to be child universes of our black hole universe, we can have the hierarchically layered structure of a child black hole universe from the hierarchically layered structure of a black hole given by Figure 6 through replacing the words "Black Hole" by "Child Universe", "Child Black Hole" by "Grandchild Universe", "Baby Black Hole" by "Baby Universe", and "Seed Black Hole" by "Seed Universe", and so on in analogy (see Figure 8). Then, combining Figure 5, which shows the infinite hierarchically layered structure of the entire spacetime that the author previously developed with the bottommost layer to be the child universes, with Figure 8, which shows the infinite hierarchically layered structure of the child universe, we can obtain the complete structure of the entire spacetime as shown in Figure 9. The top layer is the entire spacetime (or grand universe), whose mass, radius, and entropy are infinitely large; while the density, temperature, and pressure are infinitely small. The bottom layer is the layer of seed universes, whose mass, radius, and entropy are infinitely small; while the density, temperature, and pressure are infinitely large. The second layer from the bottom is the layer of baby universe. It is the mother universe of the seed universe. Infinitely going up in analogy, we have the layer of grandchild universes which are child universes or subspacetimes of the child universe of our universe. Our universe is a subspacetime of the mother universe; the mother universe is a subspacetime of the grandmother universe; and so on. This infinitely layered complete structure of the entire spacetime can also be represented by using the mathematical set concepts as U = {...{F, F, F, ...{G, G, G, ...{A, A, A, ...{S, S, S, ...{C, C, C, ..., {Gc, Gc, Gc, ...{....{Ba, Ba, Ba, ...{Se, Se, Se, ...} }...}}}}}}...}. The radii or masses of these universes, from the entire spacetime or grand universe to the seed universes, can be $\{\infty^{\infty}$, ..., ∞^{N}, ..., ∞^{2}, ∞^{1}, ..., M^{N}, ..., M^{2}, M, 1, M^{-1}, M^{-2}, ..., M^{-N}, ..., ∞^{-1}, ∞^{-2}, ..., ∞^{-N}, ..., $\infty^{-\infty}\}$ or simply say from infinitely large ∞^{∞} to infinitely small $\infty^{-\infty}$. This clear structure or picture of the entire spacetime exhibits the completeness of the black hole universe model. Any cosmological model without clearly describing its outside and inside cannot be a complete cosmology. Our next paper will establish the full origin and evolution of the entire spacetime and further give a full description not only to the present universe, but also its past and future or pre- and post-histories.

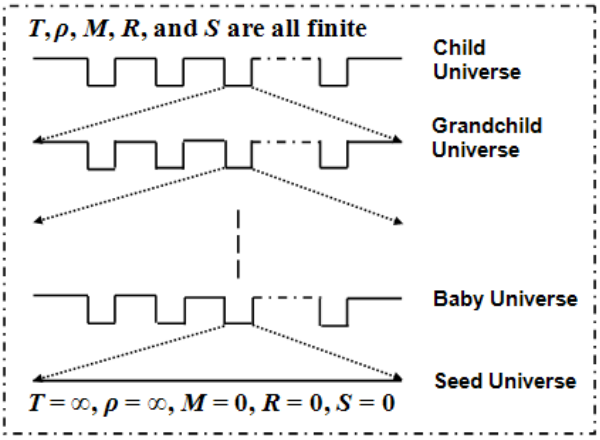

Fig. 8: The hierarchically layered structure of a child universe. Inside a child universe, there are a number of grandchild universes; inside a grandchild universe, there are a number of grand-grandchild universes; and so on in analogy. The bottommost layer is the level of seed universes, which are child universes or subspacetimes of a baby universe.

3 Summary

This study has established a complete structure for the infinite entire spacetime to be infinite hierarchically layered. First, we have constructed the internal structure of black holes or child universes as shown in Figure 6 or Figure 8. Then, we have combined the infinite hierarchically layered structure for the inside of child universes shown in Figure 8 with the previously developed infinite hierarchically layered structure of the entire spacetime that was only down to the child universes shown in Figure 5 to form the complete structure of the entire spacetime that is down to the infinitely small seed universes shown in Figure 9. The top layer is the entire spacetime, i.e. the grand universe, which has infinitely large mass, radius, and entropy and infinitely small density, temperature, and pressure. The bottom layer is the layer of seed universes, which has infinitely small mass, radius, and entropy and infinitely large density, temperature, and pressure. From the infinitely large top layer of the entire spacetime or the grand

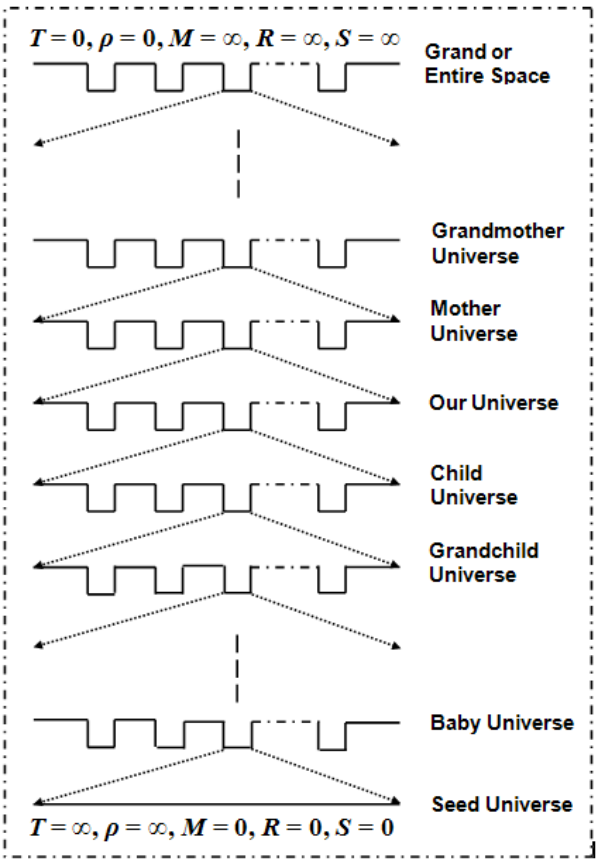

Fig. 9: The complete structure of the entire spacetime. The top or outermost layer is the entire spacetime, which is infinitely large. The bottom or innermost layer is the seed universe, which is infinitely small. The second layer from the bottom is the baby universe, which is the mother universe of the seed universe. Infinitely going up or out in analogy, they are grandchild, child, and our universes. Our universe is a subspacetime of the mother universe; the mother universe is a subspacetime of the grandmother universe; and so on.

universe to the infinitely small bottom layer of the seed universes, there are infinite layers. Our universe is about the middle finite large layer. Above or outside our universe, there are mother universes, grandmother universes, and so on. Below or inside our universe, there are child universes, grandchild universes, and so on. In addition to the complete structure of the entire spacetime, this study has also revealed the inside of black hole or child universes. This provides us a complete new view to the inside of black holes and a unique solution of the spacetime singularity as infinite asymptotically singular spacetimes.

Acknowledgements

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