Re-emergence of Cyclic Model of Universe in Conformal Cosmology

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Abstract

Although the Big Bang Model was believed to be the correct model of the universe after some experimental evidence, the laws of Physics seem to breakdown at the Big Bang singularity. So this model has some fundamental physical and philosophical problems. This review article briefly describes how the newly proposed Cyclic Conformal Cosmological Model where the Universe is an eternal succession of Aeons, tries to solve the problems of the Big Bang Model in a new way along with some of its predictions which can be verified by observation of CMBR data.

Key words*:* Big Bang, CMBR, Conformal Transformation, Black hole Evaporation,

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1. Introduction*:* One of the most fascinating inquiries of the human mind about the Origin and Evolution of the Universe has given birth to the branch of physics namely Cosmology. The Discovery of the CMBR in 1965 by Penzias and Wilson confirmed the prediction of Big Bang Model of the Universe as some kind of primordial explosion according to which the universe (the whole space-time) came into existence all of a sudden approximately 14 billion years ago. Since then It is believed to be the correct model of the universe by many scientists. However, there are some fundamental physical and philosophical problems as it is a day without yesterday and by this model, one cannot explore beyond the plank time era (10^{-43}second from the bang) and also laws of physics breakdown since curvature and temperature diverge to infinity (physical singularity) at Big Bang. However Einstein proposed a cyclic model (Einstein 1931) of the universe in 1931. But in 1934 Richard Tolman raises objections against the validity of the model by considering the Entropy of the Universe (Tolman 1934). In search for an alternative Cosmological Model, One of the most promising model emerged through a very recent research headed by Sir Roger Penrose is Conformal Cyclic Cosmology (Penrose 2006)—the view of the universe in terms of Conformal geometry rather than Lorentzian geometry and also without requiring any Quantum Cosmological theory.

2.1. Basic Idea of Cyclic Conformal Cosmology: According to this model, The Universe is eternal and consists of infinite succession of Aeon (phase of the universe from one Big Bang to the next which repeats itself indefinitely) from infinite past to infinite future. Fig shows the space-time diagram of our universe according to Big Bang Model without inflation at the beginning. At present, our universe undergoing a phase of accelerated expansion and in far future its boundary will become infinite. Now the point of singularity at the Big Bang can be stretched out to finite boundary and infinite boundary of the far future can be squashed into finite boundary by using a mathematical trick called conformal transformation under the crucial condition that physics at these two points remains to scale-invariant i.e. insensitive to the size or scale and such a condition really hold true (arguments behind such assumption will be given below). So after the conformal transformation of figure 2 it takes the form of figure 3 and the strange observation is that the physical and geometric conditions are exactly same at the point of the big bang in the past and in the far future. Now the conjecture of Cyclic Conformal Cosmology is that the far future of this present cycle of the universe in which we are living at present can be

regarded as the Big Bang of the next universe yet to be born and our big bang at the past is the far future of another universe of the past.

2.2. **Our universe in the far future**: According to recent observation that our galaxy contains a black hole at its center and it will eventually swallow all the mass of galaxy and same will happen for other nearby galaxies and they will come together and merge to form a new giant black hole. In this way all the mass of the universe will eventually be swallowed up by black holes and the universe will be left with the remnant of such super massive black holes. Now according to Hawking (Hawking 1974), a Black hole emits radiation and so its mass will decrease and it will evaporate eventually by the explosion of huge amount of radiations containing photons only.

2.3. Our universe in the past i.e. at the Big Bang: Near the Big Bang temperature was very high and the particles of the materials at this very temperature moves with very high very velocity so the energy in their rest-mass can be neglected with respect to kinetic energy so one can consider the particles as containing almost zero rest mass. So again we are in a physical condition where the universe can be regarded as filled with huge amount of radiation only.

2.4. The condition/Scenario of Scale Invariant Physics: 1. According to the general theory of relativity any space-time manifold can be best explored by its Causal structure i.e. arrangements of Light Cones at different points of the Space-time. Material particles follow the world line or trajectory through the space-time must always have to be passed inside these light cones at every points of its trajectory and the hyperbolic surface inside the cone calibrates its time scale as shown in figure 1. But photon always lies on the surface of the light cone and in principle don't experience the passing of time. Light cone in a sense represents mathematically the metric of space-time in which all the information about space-time is encoded. Metric g has total 10 components out of which 9 components uniquely specify light cone structure but the 10th component is related to the scale of the geometry and not related to photons behavior. So Photons are essentially scale insensitive.

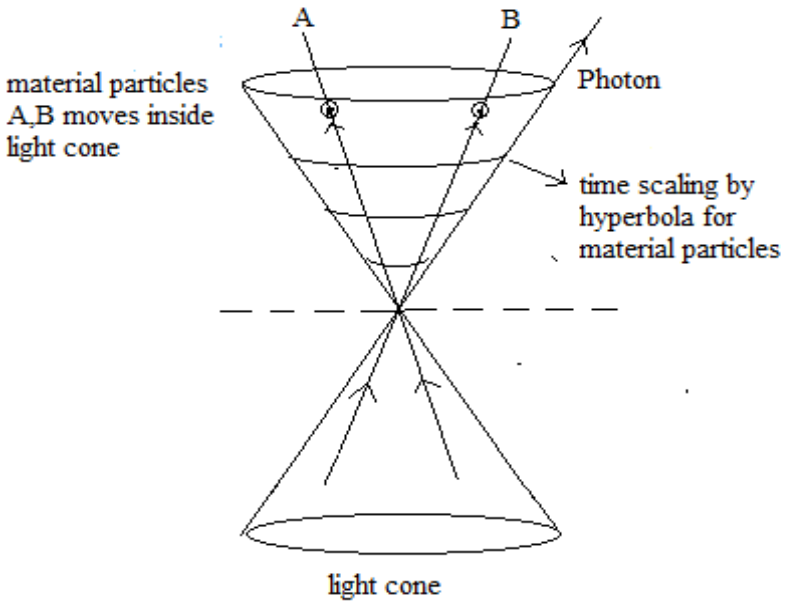

Figure 1 Material particles A,B moves always inside light cones and keep track of time .Time scaled by Hyperbolas. Photon moves on the surface of light Cones**.**

It follows from another different arguments: Two most fundamental equation of the 21st century are Plank formula for radiation energy: $E=h\nu$ and Einstein Mass Energy Equivalence Formula: $E=mc^2$.So combining these two formula it gives $\nu=mc^2/h$. The physical interpretation of this formula is that every stable particle with non zero rest mass behaves as a clock with extreme high precision. (for example atomic clock). So only material particles can keep track of the time in the universe but photons does not. So when the physics of the universe can be described by radiations or photons only, it does not distinguish between largeness and smallness of time and length. This is the key feature for this cyclic conformal model. Now conformal geometry is a geometry which is independent of scale and the use of conformal geometry here changes the whole game. By conformal transformation causal structure remains invariant and infinity can be brought back to finite size (as is most popularly done in drawing Penrose diagram and nothing peculiar about it) keeping its physics essentially unchanged and also by following same line of arguments (Paul Tod 2015) initial point at the Big Bang can be stretched out to a finite boundary (Fig-2) as at that point universe contains almost zero rest mass particles which satisfy the condition scale invariance description of physics. The boundary of Big Bang of one cycle can be smoothly matched with the far future boundary of the universe of previous cycle. Similarly Boundary of the far future of a cycle can be matched to the next cycle's Big Bang which is yet to be born. This reveals the eternal picture of the Universe with succession of Aeons (Fig-3) and in one of the Aeon we live at present.

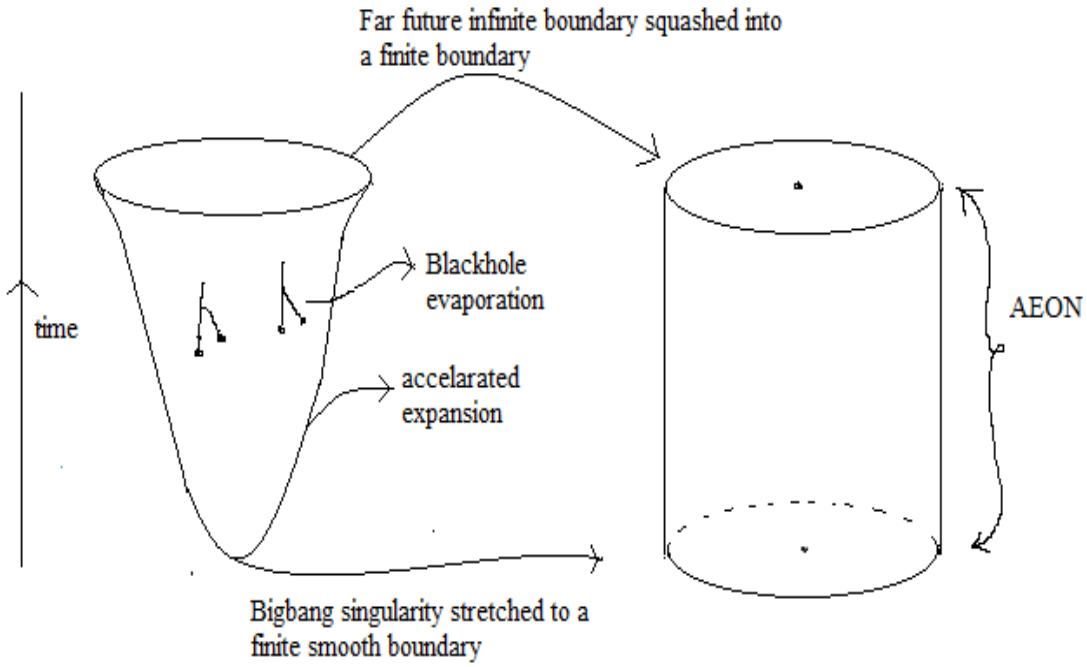

Figure 2: left figure shows our universe and right figure is obtained after conformal transformation of the left. Big Bang singularity can be stretched to finite smooth boundary and infinity of far future can be squashed to finite size.

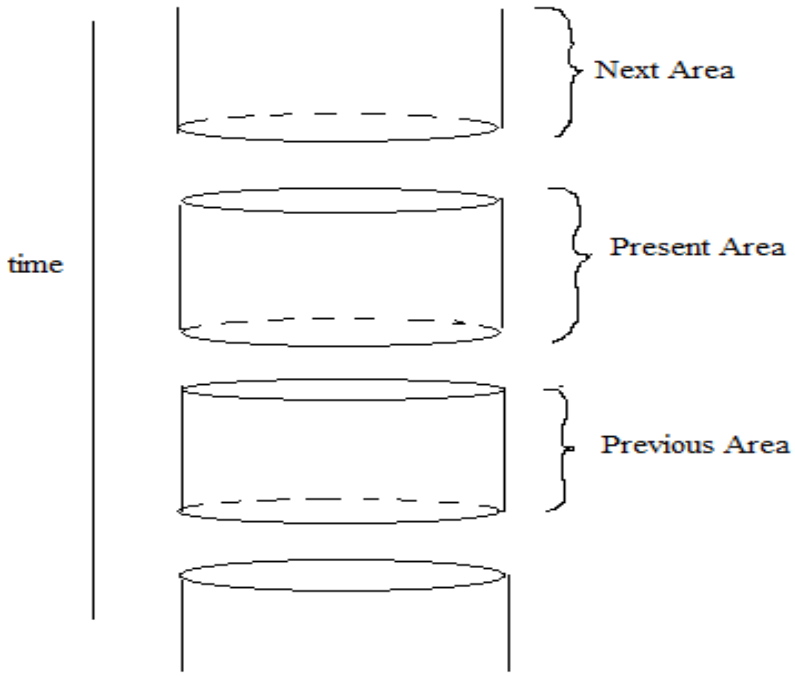

Figure 3: Big Bang in the past have same physical and geometric condition as of the far future of an expanding universe. So universe can be viewed as eternal succession of Aeon (interval between successive Big Bangs

3. Non Existence Singularity at Big Bang in Conformal Model*:* At Big Bang singularity all components of curvature tensor remains finite except the component concerning "scale" of geometry and so it is difficult to deal with as long as we adopt Lorentzian geometric description of the universe. Now as conformal geometry is not dependent of any scaling but preserve other geometric relation so no singularity is exhibited there as in the case of Lorentzian description.

4. Resolution of Entropy puzzle*:* In the far future of an Aeon, all the matters will be swallowed up by super massive black holes and a black hole can contain a huge amount of entropy than any other object or system in the universe. According to Sir Roger Penrose when the black hole evaporates by Hawking radiation all the entropy or information will be lost forever which to some scientific view seems to violate one of the most fundamental principle of quantum mechanics known as the Unitary Principle which is a statement regarding conservation of probability of the system. But during any measurement on the system when a system jumps to any particular state Unitary is always violated so according to Prof. Roger Penrose, Quantum mechanics may not be the complete description of Nature and there is a problem with the view that information is not conserved or totally lost from Universe as black hole evaporates. So as according to conformal cyclic cosmology far future of one Aeon is the beginning of the next or big bang of the next cycle so one can starts with zero entropy of the Universe. Starting with zero value of entropy is a stringent requirement of a cosmological model to be valid if it is to be consistent with the second law of Thermodynamics.

5. Prediction and Observational Verification*:* (Hawking Points in the sky and possibility of detection of signal from previous Aeon). Large super massive black holes will evaporate in the far future of an Aeon by the explosion with a huge amount of radiations and when the infinite boundary is squashed down to a finite boundary it will be concentrated in some region forming a spot after conformal transformation and will smoothly

pass through the cross over the surface to next Big Bang of the succeeding Aeon (Fig-4). This spot expands after Big Bang and left an imprint on CMBR with a region of the diameter of 4 degree which is the 8th times the diameter of the Moon in the Sky. This is called Hawking points (An, Meissner, Nurowski and Penrose 2018) as it originates from Hawking Radiation. Plank satellite data and other data of CMBR show such a spot with a very high statistical confidence level. Till date there is no other cosmological explanation except the interpretation of those spots as Hawking points which imply the existence of some previous Aeon of the Universe. However, Inflation is not required in this model as it would spoil out all the evidence from previous Aeon.

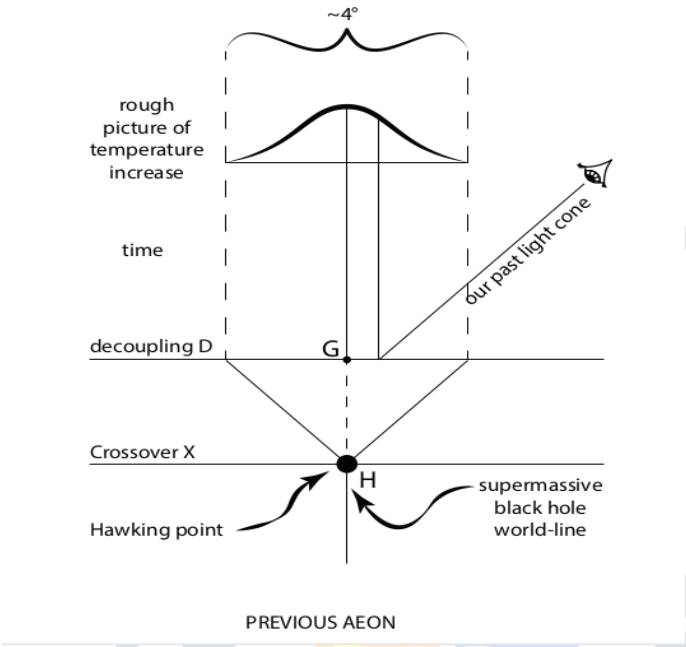

Figure 4: Signal from Hawking points transmitted through the cross over surface between Aeons and left an imprint on the CMBR as spot of 8 times the diameter of moon in the sky (4 degree).

6. Conclusion: This cosmological model is superior and appealing than other models as it solves two puzzling features e.g. Big Bang Singularity and Entropy Problem which are present in other known cosmological models. Also eternity of the Universe answers to some fundamental philosophical problems also. However, only the confirmed discovery of signals from previous Aeon (Hawking points, etc.) in the future can establish this model as the correct description of our Universe.

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