**Was our Universe Created by a Black Hole? – Charles Peterson**

**Project Description & Goals:** The goal of my project is to operationalize and test a primary alternative, referred to as Black-Hole Cosmology (BHC), to the standard Big-Bang theory explaining the origin of our Universe. In the first part, I propose to write and use a computer program, based on the existing theoretical framework (Popławski 2014), to model the creation of a universe inside a black hole. In the second part, I plan to compare the quantitative predictions of this model to the observational data from the Cosmic Microwave Background (CMB) radiation (Planck collaboration 2014). The CMB provides a lot of information about the dynamics of the very early Universe, allowing me to substantiate or rule out the BHC.

**Background & Rationale:** In 1927, Lemaître proposed that our Universe was very small, dense, and hot, and then expanded, which is referred to as the Big-Bang theory. In 1929, Hubble discovered that the Universe is expanding. In 1948, Alpher et al. showed that this theory agrees with the observed amounts of the lightest elements in the Universe. In 1965, Penzias and Wilson discovered the CMB radiation coming from all directions in the sky. This radiation is a sort of footprint left behind by the very early, hot Universe, and strongly supports the Big-Bang theory. However, this theory did not explain why the Universe looks the same in all directions. To answer this question, physicists came up with an idea of inflation. Inflation theory argues that the Universe’s identical appearance can be explained by its very rapid and symmetric expansion immediately after the Big Bang. Inflation theory gained more credibility because it correctly predicted that the CMB temperature slightly changes with the direction on the sky, which was consistent with data discovered by the COBE satellite in 1992.

The biggest problem of Big-Bang cosmology, however, is its prediction that the Universe started from a point of infinite density. This prediction makes no physical sense and indicates that our understanding of the physics of the very early Universe is incomplete. The inflationary paradigm has yet to solve this problem. Moreover, to arrive at these consistent predictions of temperature changes, inflation theorists introduce hypothetical types of matter that have not been observed and rely on models that must be frequently adjusted to match existing observational data. In addition, the Big-Bang theory with inflation fails to address the most fundamental question: what reality existed prior to the Big Bang?

The answer to these problems may come from BHC, which argues that our Universe was created from a black hole (a region of space from which nothing can escape) existing in another, parent universe. Very massive stars end up as black holes, where matter collapses into smaller regions of space. Then when this condensed matter reaches an extremely high density, it stops, and rapidly bounces outward to a new region of space. After the bounce, this black hole would then become a doorway to a new, growing universe. Accordingly, our own Universe could be the interior of a black hole existing in another universe (Pathria 1972, Popławski 2010).

While BHC is simpler than inflation (i.e. does not require hypothetical matter), it has yet to generate specific predictions about the observed CMB temperature fluctuations. These fluctuations provide the most important data currently used by cosmologists studying the early Universe. The proposed research will extend BHC by generating predictions about those temperature fluctuations to evaluate this theory’s validity.

**Methodology:** Operationalizing the BHC theory and testing it against empirical data will unfold in two parts. First, I will create a computer program that will model the creation of a universe inside a black hole. This program will numerically solve a system of two coupled, ordinary, first-order differential equations, which are the Einstein-Cartan equations of general relativity with spin and torsion (Sciama 1964), applied to a universe and modified by quantum production of particles from vacuum in strong gravitational fields near a bounce (Popławski 2014). Particle production should greatly increase the mass inside the black hole. The universe may undergo several bounces until it has enough mass to expand to infinity as our Universe does. I will analyze how the rate of particle production affects the number of bounces and the final mass of the universe.

Second, I will evaluate the hypothesis that our Universe was created in a black hole by comparing the prediction generated in the first part of the project to the CMB observational data. Since the rapid recoil after the Big Bounce could be what has led to our expanding Universe, the results of this recoil should match observations of the universe's size and mass as functions of time, its geometry, and several variables which describe fluctuations in the CMB temperature. After running the computer program for a range of the values of the particle production rate, I will compare its numerical results to the data recorded from the CMB observations.

**Expected Outcomes & Broader Implications:** I argue that a black hole can create a universe that has the characteristics of our Universe. The mathematical model I am proposing to compute contains only one variable that can be changed: the *particle production rate*. One variable makes this model more robust than inflation theory, which relies on two variables. Finding a predicted value of this rate that matches all observational data would substantiate BHC. The lack of such a value would rule out BHC or require major modifications.

Additionally, if BHC’s predictions are consistent with the CMB observational data, this implies that our current understanding of gravity and high-energy physics may need to be modified (Kibble 1961). In short, there may be new forms of energy that we have not yet discovered. These new forms of energy could revolutionize energy production and even space travel. Regarding space travel, if these new forms of energy exist, then we could significantly increase the speed of travelling through space, drastically cutting space travel time to Jupiter from two years to several hours.

**Personal Statement**. As an engineering student who has a deep appreciation of science, I think it is crucial for engineers to find what inspires their creativity. For me it is space exploration. I want to work for NASA or Lockheed and Martin developing spaceships. I believe that this experience will cultivate my desire for space exploration. I also believe that I will develop a better understanding for writing codes for computers to mathematically analyze and model real life scenarios. I will also learn more about the math and physics of space, especially in the field of gravity. This opportunity will help provide me with unique experiences that will prepare me well when I apply and work for a space exploration company I will excel. This is not about me being getting a job. Obtaining and experiencing the Summer Undergraduate Research Fellowship at its core is about creating my career. Moreover, it is about me learning the difference between what it takes to succeed and fail in a project.

**Budget**

I possess everything required for this project. There are no budgetary requirements for this project.