

# The Dark Side Of General Relativity: Unveiling the Enigmatic Secrets of the Cosmos

General relativity, the groundbreaking theory formulated by Albert Einstein over a century ago, has been regarded as one of the pillars of modern physics. Its profound insights into the nature of space, time, and gravity have revolutionized our understanding of the universe. However, beneath its glamorous façade, lies a mysterious side that challenges our perceptions and pushes the boundaries of human comprehension.

Contrary to popular belief, general relativity is not all about the glamorous attractions of beautifully curved spacetime, cosmic ballets, and exotic phenomena like black holes and gravitational waves. It has a darker side, characterized by intricate enigmas that continue to confound even the brightest minds in the field.

## The Illusion of Certainty

Despite its wide acceptance, general relativity is far from being a complete theory of gravity. While it provides remarkable explanations for a vast range of observations and experiments, there remain profound questions that elude our understanding. One of the major limitations lies in its inability to incorporate the principles of quantum mechanics, the other great pillar of modern physics.

### The Dark Side of General Relativity

by Mendon Cottage Books(Kindle Edition)

★★★★☆ 4 out of 5

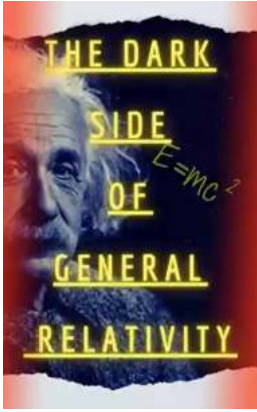
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The quest for a unifying theory that reconciles general relativity with quantum mechanics, commonly known as a theory of quantum gravity, has been a holy grail for physicists for decades. Such a theory would pave the way towards a more complete picture of the universe, but the path to its realization is filled with obstacles and complexities that continue to baffle scientists.

## **The Puzzle of Dark Matter and Dark Energy**

Another perplexing aspect of general relativity lies in its inability to account for the mysterious substances known as dark matter and dark energy. These invisible entities dominate the composition and dynamics of the universe, yet their true nature remains elusive.

Dark matter, which makes up about 85% of the matter in the universe, does not interact with electromagnetic radiation and is therefore invisible to conventional detection methods. Scientists hypothesize its presence based on the gravitational effects it exerts on visible matter, but its actual composition remains unknown.

Dark energy, on the other hand, is believed to be responsible for the accelerated expansion of the universe. Its presence was first inferred from observations of

distant supernovae, but its origin and nature are still shrouded in uncertainty. General relativity, in its current form, fails to provide a satisfactory explanation for both dark matter and dark energy, leaving researchers grappling with major gaps in our understanding of the cosmos.

## **The Warped Concept of Time**

One of the most mind-bending aspects of general relativity is its effect on the fabric of spacetime and our perception of time itself. According to Einstein's theory, massive objects distort the fabric of spacetime, causing time to flow at different rates in different regions.

This phenomenon, known as gravitational time dilation, has been experimentally confirmed and has practical implications for GPS systems and space exploration. However, it leads to peculiar scenarios, such as time running slower near massive objects or the possibility of time travel in extreme scenarios, challenging our intuitions about the nature of time.

## **The Ultimate Fate of the Cosmos**

General relativity also leads us to contemplate the ultimate fate of our universe. Based on its predictions, there are three potential scenarios: a closed universe that will eventually collapse in on itself, an open universe that will expand indefinitely, or a flat universe on the brink of expansion cessation.

While the current observations suggest that our universe is more likely to be open or flat, the final outcome remains uncertain. The eventual fate of the cosmos is intimately intertwined with the unresolved mysteries of dark matter, dark energy, and the unifying theory of quantum gravity, making it a subject of fervent debate among cosmologists.

## **Navigating the Darkness**

Study and exploration of the dark side of general relativity present an exhilarating journey for physicists and cosmologists alike. It prompts us to question our assumptions, challenge established theories, and push the boundaries of our understanding.

By delving into the enigmatic aspects of general relativity, researchers are paving the way for breakthroughs that will shape the future of physics and cosmology. Unraveling the mysteries of dark matter, dark energy, and time dilation could provide profound insights into the nature of the universe, while a theory of quantum gravity promises to unite two of the greatest theoretical frameworks in history.

As we embark on this fascinating quest, we must embrace the darkness and step into the unknown, driven by curiosity and the desire to uncover the true nature of our cosmos.

The dark side of general relativity challenges us to redefine our understanding of the universe. Its limitations, enigmas, and uncertainties drive us to seek answers that lie beyond our current knowledge. The pursuit of a theory of quantum gravity, the unraveling of dark matter and dark energy, and the exploration of spacetime's warped fabric lead us to the cutting edge of scientific inquiry.

Embracing the darkness, we illuminate the path to new frontiers, guided by the curiosity and the unyielding spirit of discovery that shape our understanding of the cosmos.

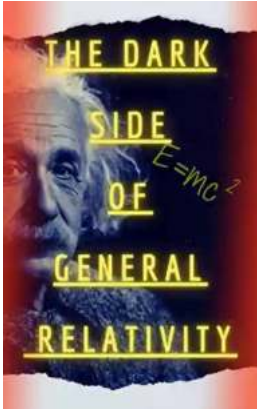
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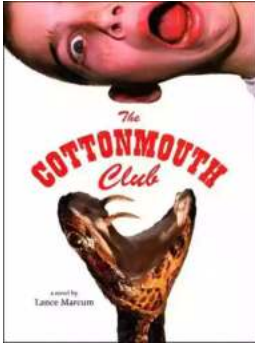
Motivated by the recent gravitational wave detections, we consider primordial black holes as a valid alternative to a significant fraction of dark matter. At the moment, there is no experimental evidence of such an object, but the event called GW190814 has detected a compact object of 2.6 times the sun mass. It is therefore either the most massive neutron star or the lightest black hole ever detected. But it could also be a primordial black hole and we will consider different aspects of gravitational waves related to primordial black holes. First, we used the code developed by the Einstein Toolkit community to solve numerically the Einstein equations and calculate the gravitational wave-forms emitted by a binary black hole merger. These wave-forms are valid for any mass of the system thanks to the scaling relations for black holes described by the Kerr metric. We can thus easily have the wave-form for black holes having a mass of the order of a gram up to millions of solar masses. These scaling relations are also valid for charged black holes but there are more exotic black holes that break the scaling relations. We will also study the physical limits of these relations by considering the expansion of the Universe and Hawking radiation, which can become non-negligible for primordial black holes. When a gravitational wave signal is detected by the LIGO/Virgo collaboration, the detected objects are classified as neutron stars if their mass is lower than 2.2 times the sun mass and as black holes if their

mass is higher than 5 times the sun mass. But if we do not want to use this distinction, we must be able to distinguish the effect of baryonic matter describing a neutron star through the tidal deformability. We will study the necessary conditions to determine the nature of compact objects by injecting wave-forms into a realistic detector noise. There are many candidates to describe dark matter and primordial black holes are one of them. The Fuzzy Dark Matter model based on a scalar field is another one and it is possible to extend this model to also mimic the behavior of dark energy. We will study the potential of such a model to give the most general form. At low energy, the two basic ingredients are: an extremely low mass term and a constant dominating the recent evolution of the Universe to replace dark energy. However, the shape of the potential remains an open issue because it is not very constrained in the primordial Universe. On the other hand, it is possible to give limits on the energy density of a generic scalar field during Big-Bang nucleosynthesis by the observed abundance of the elements. These limits are given: for a stable scalar field and for a scalar field decaying into radiation. There are many models using scalar fields in cosmology, to reduce their number, a solution is to consider them as non-independent. For this, we will introduce a triple unification model unifying: inflation, dark matter and dark energy with a single scalar field with a non-minimal coupling to gravity.



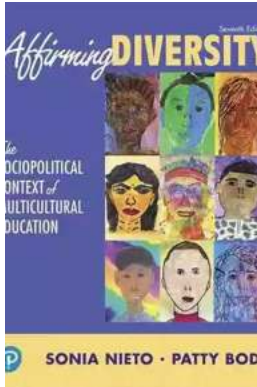
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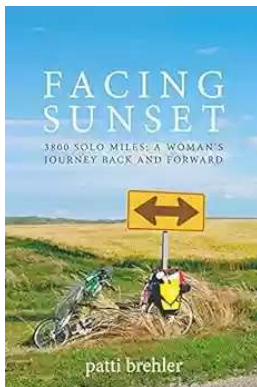
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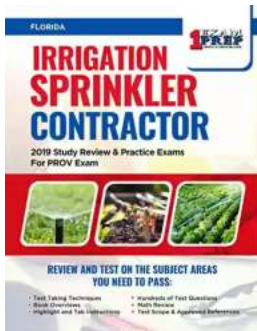
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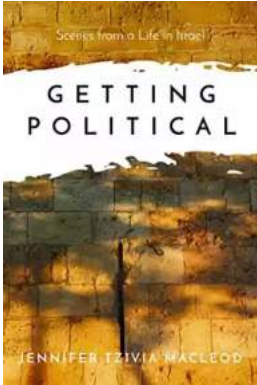
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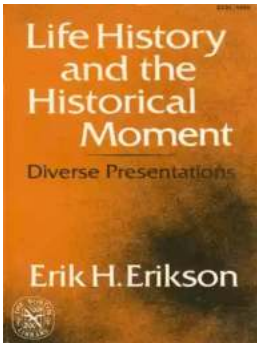
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