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To Understanding the Concepts of Dark Energy and Dark Matter and Calculation of Dark Energy and Dark Matter

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Abstract

Cosmologists believe that the majority of the universe is made up of two unexplained "dark" components: one that acts to avoid collisions and bind galaxies together, and another that exerts a negative isotropic pressure and speeds up the expansion of the universe. This idea is supported by a growing corpus of observational data that has been gathered over the last several decades. Together, these parts account for around 96% of the universe's total energy budget at this time. Around 74% of the universe's mass is made up of dark energy, whereas just 25% is made up of dark matter, which is six times as common as visible matter. Only 4% of the universe is made up of visible stuff, making it a relatively small part. Dark matter and dark energy have so far been inferred through the impacts of their cosmic dynamics. However, attempts to identify their makeup and mode of interaction have not proven successful. This inquiry takes into account the ideas and theories of other scientists in order to get a fuller picture of dark matter and energy. The purpose of this study is to better understand the components of dark matter and dark energy. With the aid of secondary sources and the opinions of various experts, a hypothesis that sufficiently describes the notions of dark energy may be established. The cosmological principle says that the cosmos is uniform and almost isotropic on sizes larger than individual galaxies. One of the main goals of current cosmology is to determine what forms of matter exist in the universe and how abundant they are. Only 4.5% of the visible cosmos is made up of baryonic matter; the remaining 73.8% is composed of dark matter and energy. Early observations, like as Doppler redshift measurements of galaxies in the Coma Cluster, indicated that the velocities of galaxies could not be explained by the motions of visible matter alone. Further evidence, including the study of galaxy rotation curves and the Cosmic Microwave Background, has confirmed the presence of dark matter, which interacts solely through gravity.

This research indicates that dark energy plays a dominant role in the universe's accelerated expansion, constituting approximately 74% of the cosmic energy budget. Despite this, the true nature and origin of dark energy remain elusive. Various hypotheses, including the cosmological constant and modified matter models, have been proposed, each with its limitations and challenges. The study delves into the theoretical underpinnings of dark energy, highlighting its connection to quantum physics and the concept of vacuum energy. While quantum physics suggests that energy can arise from empty space, it is essential to recognize the significant discrepancies between quantum predictions and observable dark energy, leading to the cosmological constant dilemma.

The study also discusses the zero-energy universe concept, which posits a balance between positive mass energy and negative gravitational potential energy, offering an intriguing perspective on the cosmos' energy dynamics. A thorough literature review provides insights into the current state of research on dark matter and dark energy. Scientists employ various methods, such as gravitational lensing, power spectra analysis, and N-body simulations, to probe these cosmic mysteries. Finally, the research objectives and methodologies employed in this study are outlined, emphasizing the use of both quantitative and qualitative approaches, including surveys of experts in the field.

Keywords: Dark Energy, Dark Matter, Cosmology, Astrophysics, Universe, Gravitational Lensing

Introduction

Studying the theoretical foundations of dark energy and dark matter is the emphasis here. At the conclusion of my study, I will outline four conditions necessary for a spectacular hypothesis that might successfully explain dark energy. However, there are significant gaps in the coverage of the many ideas attempted to explain the causes and consequences of dark energy.

A major focus of modern cosmology is determining what kinds of matter exist and how much of each kind there is. The visible universe seems to be composed of baryonic matter (4.5% of its total mass) together with dark matter (22.7%) and dark energy (72.8%).Doppler redshift was employed to calculate the velocity dispersion of eight Coma Cluster galaxies. He calculated the speed of the cluster's galaxies and discovered that it was around 10 times quicker than he had anticipated. (Thabet, 2014)

Only around 0.5% of the mass required to speed up the galaxies was visible stuff. More clusters were seen by Rubin, Freeman, and Peebles in the 1970s, offering more proof that the incredible speeds at which the galaxies move cannot be accounted for by the luminous matter alone. If every portion of a spiral galaxy blazed brilliantly, the galaxy's rotation rate would slow as it approached the edge, where star formation was taking place at a slower pace. Unfortunately, reality doesn't function that way. Galaxy rotation curves that we now understand are flat. Invisible dark matter was discovered thanks to research into the cosmic microwave background (CMB) and the movements of galaxies and galaxy clusters.

Recent evidence suggests that dark energy is the dominant force in our rapidly expanding cosmos. Consistent evidence from the Cosmic Microwave Background (CMB), Type la Supernova observations, and baryon acoustic oscillations (BAO) shows that dark energy accounts for around 74% of the current cosmic energy budget. Its true nature and origin, however, remain ill-defined. Dark energy has been seen to remain surprisingly constant over cosmic time and space. Several hypotheses have been proposed to explain dark energy's make-up and where it came from. The inhomogeneous model and variations on the modified matter model are only two of the many unsubstantiated ideas about the vacuum energy density. The cosmological constant, and the parameter in its equation of state, are both fixed at $w = -1$. However, the cosmic constant suffers from two significant flaws: the first is the problem of coincidence, and the second is the problem of excessive fine-tuning.(Garrett, Katherine & Duda, 2011)

Similar to how vacuum energy functions within the setting of quantum physics, dark energy does its thing inside the framework of classical general relativity. Energy may be created out of thin air, according to quantum theory. This theory allows for the creation and destruction of particles having mirror-image symmetry, such as atoms and associated antiparticles.

These elementary particles produce energy by briefly appearing and disappearing all around the cosmos. As more vacuum energy is created, the universe accelerates in its pace of expansion. However, owing to a difference of around a factor of 1012, one should be wary of predictions based on quantum effects. That traditional quantum physics alone can't account for observable dark energy without major revisions is the root of the cosmological constant dilemma. Several more hypotheses have been proposed by scientists to account explain dark energy, in addition to the standard and semi-classical models. As a result, we still don't know what dark energy is made of.(Casas, J. A., Garcia-Bellido, J., & Quiros, 1992)
According to the concept of a zero-energy universe, the combined mass energy and gravitational potential energy are zero. The quantity of positive energy contained in the cosmos as matter is precisely balanced by the amount of negative energy represented by gravity. This shows that the whole potential energy of the cosmos has been expended.(Berman, 2009)

Concepts and Theories about Dark Matter

In cosmology and astronomy, dark matter is a hypothetical concept. Dark matter (also known as baryonic matter; its smallest unit is an atom) behaves differently from regular stuff such as planets, stars, and galaxies. For example, unlike regular matter, dark matter has no discernible interaction with electromagnetic radiation. It is difficult to detect since it does not give out or take in any electromagnetic radiation. Its gravitational influence on detectable stuff is the sole evidence for its existence since dark matter seems to dominate regular matter by a factor of nearly five to one, its percentage in the universe's total energy density has been calculated to be about 23%. About 4% of the whole is made up of "normal" parts. It has been theorized via computer simulations that dark matter permeates the whole universe, and if this is the case, then the path of Earth's orbit around the sun would be strewn with the debris of dark matter particles.(Riess, 2023)
Most scientists now agree on dark matter's existence, although they still don't know much about it. In order to solve this mystery, candidates for dark matter are classified as either baryonic or non-baryonic. In the search for baryonic candidates, massive compact halo objects (Machos) are taken into account. Halos encircling galaxies are composed of objects called machos, which are difficult to detect because to their low luminosities. Every stellar object, from brown dwarfs to neutron stars to black holes to white dwarfs, is unique in its own way.
Instead of employing space telescopes to see Machos, gravitational lensing may be used. As Albert Einstein proved in 1919, gravity creates a warping of space time that alters the path of all types of radiation, including light. He hypothesized that light from a star aligned with the sun would be refracted by the sun's gravity. The lensing of light rays may produce an image or pictures of a star for an observer. If a black hole blocks our view of a distant galaxy or star, we will never see them in our lifetimes, that galaxy or star will seem stretched out, or "lensed," to the observer on Earth. It's feasible that a black hole or some other really big object is creating the illusion that the stars are moving around it. The area around a black hole could experience gravitational effects. When stars are seen to be orbiting a strange, invisible object, the existence of a black hole becomes the most likely explanation. The black hole was found in 1995 by an international team of astronomers headed by Japanese and American scientists. Its mass is 36 million times that of the sun. This progress is somewhat dampened by the fact that scientists have not yet discovered sufficient Machos to account for all of the universe's dark matter.(Tillman, 2023)

Particle physicists have suggested non-baryonic particles with weak interactions with standard matter as a possible explanation for dark matter. The most likely possibilities for these particles are weakly interacting massive particles (WIMPs). It is hypothesized that these hypothetical particles have mass, but their interactions with ordinary matter are so faint that they are practically difficult to detect. If these particles interacted with regular matter, particle researchers say, they may release measurable radiations. Such opportunities for gatherings, however, are quite uncommon. Some examples are axion, photino, and neutralino. Scientists are in agreement that baryonic MACHOs or non-baryonic WIMPs might make up dark matter.

Some physicists still dispute the existence of dark matter. To account for events that are thought to be produced by dark matter, many modifications to Newtonian and Einsteinian gravity have been proposed. Competing cosmic gravity theories include the Tensor-vector-scalar (TeVeS) model and Modified Newtonian Dynamics (MoND). A minority of scientists have proposed an alternative theory, which holds that dark matter is only a quantum mechanical illusion. The discovery of dark matter and the identification of its constituents remains an important objective in the study of the cosmos.

Dark Energy

Since Edwin Hubble's 1929 discovery of an expanding cosmos, astronomers have theorized that gravity is slowing the expansion of the universe. It seems to reason that this is the case, given that every stuff in the universe is attracted to all other matter by gravity. In theory, the gravitational attraction of an object increases as its mass increases. However, scientists were still unsure as to whether or not gravitational force was sufficient to slow or even reverse the expansion of the cosmos. Or would the cosmos collapse in on itself and expand forever if it didn't exist? Perhaps the gravitational force was moderate enough to keep the rate of expansion constant. It has been hypothesized by scientists that the attraction of gravity would eventually halt the expansion of the universe.

Astronomers made their initial measurements of the universe's slowing expansion in the 1990s. Assuming that gravity's rules apply everywhere and that dark matter exists, they did expect an acceleration in the rate of expansion to slow down. Scientists have considered the possibility of using supernovae as "standard candles" at very great cosmological distances to gauge the expansion rate of the universe. They found it surprising that the rate of the universe's expansion had increased.Since the rate of cosmic expansion has suddenly sped up, something must be working against gravity. This "something" has been given the name "dark energy" by researchers.

Cosmic microwave background (CMB) data, baryonic acoustic oscillations, and the weak gravitational lens are all indicators of dark energy's existence. Dark energy has been associated by some with the anti-gravity force. The effects of its gravity on Earth are negligible, but the ripples it causes in the expansion of the universe are far-reaching.(Don Lincoln, 2023)

Research objective

The research objective aimed at identifying and setting an understanding on the concept of dark matter and dark energy

Research methodology

Quantitative and qualitative methodologies were used most often in the investigation. In contrast to the statistical analysis and numerical components favoured by the quantitative method, the most fruitful implementations of the qualitative approach rely on an exploratory strategy informed by any unstructured data. The research technique was established by drawing on both primary and secondary resources. Due to its widespread availability and absence of preparation requirements, secondary data (which may be obtained in a number of books and articles) has been used extensively. This method requires the analysis of archival data from related research, journals, books, and other publications. Email questionnaires sent to a sample of specialists in the field were the primary method of data collection.

Research instruments

Using specific information-gathering tools, the suggested methods were put into action. The major instrument for gathering information in this research was a questionnaire. Those engaged were polled using a battery of questions. The survey will include questions like these.

Research sample

50 experts from all across the globe were used to create the sample population. Their identities, residences, and the names of the forms and businesses they represent came from both official and covert sources. The method that was used was known as "single formatting.

Analysis

Dark matter and dark energy have been a mystery in the past few years did you agree with that the scientists and astronomers need to do more to solve it?		
	Frequency	Percent
strongly agree	20	40.0
Agree	9	18.0
Neutral	5	10.0
Disagree	7	14.0
Strongly disagree	9	18.0
Total	50	100.0

Statement 1

Dark matter and dark energy have been a mystery in the past few years did you agree with that the scientists and astronomers need to do more to solve it?

Aim of the statement

Global research effort has expanded as a result of the introduction of new technologies and the pace of globalization. These research lead to the creation of fresh, unique items. To elicit feedback from the respondents on how these technological breakthroughs have impacted society, this claim has been included to the poll.

Analysis

Because the premise was overwhelmingly supported by the respondents, the answers to this claim seemed to be self-evident. They thought that more research could be done to analyze and compute dark energy and dark matter.

The vast majority of responders stressed a crucial point: despite intensive study, scientists have not been able to communicate to the general people the fundamentals of the dark enigma (read: dark energy and dark matter). Unanswered fundamental issues include why dark energy hasn't been identified yet, why it doesn't produce radiation, how it may be explained, and how it might be exploited. Therefore, the respondents believed that making a greater effort may result in good things.

Did you agree with that the calculations done by many researchers to calculate dark energy are valid, because not all researchers have validated the calculations?		
	Frequency	Percent
strongly agree	15	30.0
Agree	9	18.0
Neutral	11	22.0
Disagree	8	16.0
Strongly disagree	7	14.0
Total	50	100.0

Statement 2

Did you agree with that the calculations done by many researchers to calculate dark energy are valid, because not all researchers have validated the calculations?

Aim of the statement

This remark is meant to bolster the theory that dark energy makes up 68% of the universe, dark matter 27%, and regular matter 5%. Feedback in this section would be helpful in evaluating whether or if professionals and scientists in this field have accepted these data since they have been published in the research for some time.

Analysis

Many of those polled just chose "neither agree nor disagree," indicating that they struggled to come to a conclusion on how to reply. However, many others argued that more study needed to be conducted and made public before consensus could be reached.

Did you agree with that Positive energy is practically equal to negative energy as stated in various theories, is it acceptable with respect to

law of physics?		
	Frequency	Percent
strongly agree	16	32.0
Agree	7	14.0
Neutral	13	26.0
Disagree	8	16.0
Strongly disagree	6	12.0
Total	50	100.0

Statement 3

Did you agree with that Positive energy is practically equal to negative energy as stated in various theories, is it acceptable with respect to law of physics?

Aim of the statement

Scientists have discovered a shocking conclusion after reviewing the available evidence and hypotheses: positive and negative energy are essentially interchangeable. This topic has been the subject of several discussions and disagreements. It could be instructive to review this remark with the associated literature and the comments to it.

Analysis

The vast majority of respondents agreed with this remark wholeheartedly, making its meaning seem self-evident. Edward Tylon postulated a universe devoid of energy in 1973. According to the theory, there is zero net energy since the positive energy from the mass and the negative energy from gravity cancel each other out. It's feasible that there are about equal quantities of matter (which represents positive energy) and gravity (which represents negative energy) throughout the cosmos. So, the total energy of the cosmos is nothing. Most respondents thought that even in this case, massive quantities of energy would have been needed to cause inflation.

Did you agree with practical calculations on the theoretical percentages of dark energy, dark matter and baryonic matter?		
	Frequency	Percent
strongly agree	19	38.0
Agree	8	16.0
Neutral	11	22.0
Disagree	6	12.0
Strongly disagree	6	12.0
Total	50	100.0

Statement 4

Did you agree with practical calculations on the theoretical percentages of dark energy, dark matter and baryonic matter?

Aim of the statement

Scientists have theoretically calculated the amount of dark energy. However, they have failed to do so practically. In other words, the theoretical amount has not been validated practically. Recent observations and studies have shown that our universe consists of 68% dark energy and 27% dark matter. Scientists and researchers with all the instrument and measures, however, have been able to determine and observe only 5% of dark energy, which amounts for only a small percentage as compared to theoretical calculations. Aim of this statement is to validate this fact through respondent viewpoint.

Analysis

According to various studies, the amount of dark energy, dark matter and baryonic matter present in universe is approximately 72.8%, 22.7% and 4.53% respectively. The responses of this statement appeared to be towards disagreement as most of the respondents were not sure about the theoretical values as it has not been justified till date. Many individuals believe that there is much more left to be discovered in this regard.

Did you agree with that Quantum theory explains that space, which is empty, is filled with virtual particles that continuously form and disappear?		
	Frequency	Percent
strongly agree	14	28.0
Agree	11	22.0
Neutral	10	20.0
Disagree	8	16.0
Strongly disagree	7	14.0
Total	50	100.0

Statement 5

Did you agree with that Quantum theory explains that space, which is empty, is filled with virtual particles that continuously form and disappear?

Aim of the statement

In particle physics, the vacuum refers to the lowest energy configuration. According to the uncertainty principle, however, states of exactly zero energy do not exist, even in vacuum (virtual particles are continuously created). These particles quickly form and disappear producing vacuum energy in the process. Physicists, therefore, argue that this ground state vacuum energy influences the dynamics of the expansion of the universe. When scientists calculated dark energy of empty space in accordance with

Quantum theory, however; they obtained 120 orders of magnitude difference between the observed and the theoretically expected value.

Analysis

Most of the respondents showed disagreement with the statement. They argued that such high vacuum energy, as observed by scientists in the laboratories, would have ripped the universe to shreds long ago; the galaxies would not have formed since acceleration of the universe would have been incredibly high. Some respondents argued that the concepts of dark energy could be explained through some dynamic fluid or field that fills the space. This fluid or field would have the opposite impact on cosmic expansion as normal matter and energy due to its negative gravitational mass. This kind of theory, known formally as quintessence models of dark energy, is very important to remember. Cosmic inflation is shown to have been caused by the dynamic scalar field. However, the existence of quintessence has not been established.

How does the study of dark matter and dark energy impact our understanding of the universe's past, present, and future, and what implications could this have for our exploration of space and the search for extraterrestrial life?		
	Frequency	Percent
strongly agree	19	38.0
Agree	7	14.0
Neutral	11	22.0
Disagree	8	16.0
Strongly disagree	5	10.0
Total	50	100.0

Statement 6

How does the study of dark matter and dark energy impact our understanding of the universe's past, present, and future, and what implications could this have for our exploration of space and the search for extraterrestrial life?

Aim of the statement

The aim of this statement is to explore the profound implications of studying dark matter and dark energy on our comprehension of the universe's history, current state, and future evolution. Additionally, it seeks to highlight the potential ramifications of this knowledge for advancing space exploration and enhancing the prospects of discovering extraterrestrial life.

Analysis

The study of dark matter and dark energy has profound implications for our comprehension of the universe's past, present, and future, with far-reaching consequences for space exploration and the quest for extraterrestrial life.

Dark matter, an enigmatic substance that makes up about 27% of the universe, influences the universe's past by shaping the formation of galaxies and galaxy clusters. Its gravitational pull plays a pivotal role in the arrangement of cosmic structures. Understanding dark matter is crucial for tracing the evolutionary history of the cosmos.

Dark energy, comprising about 68% of the universe, affects the universe's present by driving its accelerated expansion. This mysterious force challenges our fundamental understanding of gravity and the fate of the universe. To comprehend the universe's current state and predict its future, we must grapple with dark energy's nature.

These studies have direct implications for space exploration. Accurate knowledge of dark matter and dark energy is essential for planning missions, designing spacecraft, and navigating the cosmos. Furthermore, a deeper understanding of the universe's composition and evolution can guide our search for extraterrestrial life by identifying habitable zones and potential life-supporting environments.

Are there interdisciplinary approaches involving astrophysics, particle physics, and cosmology that could lead to breakthroughs in our understanding of dark matter and dark energy, and if so, what collaborative efforts are underway to explore these possibilities?		
	Frequency	Percent
strongly agree	22	44.0
Agree	7	14.0
Neutral	9	18.0
Disagree	6	12.0
Strongly disagree	6	12.0
Total	50	100.0

Statement 7

Are there interdisciplinary approaches involving astrophysics, particle physics, and cosmology that could lead to breakthroughs in our understanding of dark matter and dark energy, and if so, what collaborative efforts are underway to explore these possibilities?

Aim of the statement

The aim of this statement is to investigate the potential for interdisciplinary collaborations between astrophysics, particle physics, and cosmology in order to advance our comprehension of dark matter and dark energy, while also identifying existing collaborative initiatives in this pursuit.

Analysis

The question of whether interdisciplinary approaches involving astrophysics, particle physics, and cosmology could yield breakthroughs in our comprehension of dark matter and dark energy is a highly pertinent and complex one. Such an inquiry underscores the multifaceted nature of these enigmatic cosmic components and the necessity for cross-disciplinary collaboration in addressing them.

Astrophysics, with its focus on celestial phenomena, provides crucial observational data regarding the distribution of dark matter in galaxies and clustersParticle physics, the study of the universe's tiniest constituents, may hold the key to discovering dark matter particles. The discipline of cosmology seeks to understand the cosmos as a whole, including its expansion due to dark energy.

Collaborative efforts are indeed underway to explore these possibilities. Initiatives like the Large Hadron Collider (LHC) and experiments conducted by astrophysical observatories and cosmological surveys are prime examples of such endeavors. These efforts involve scientists from diverse backgrounds working together to probe the mysteries of dark matter and dark energy, reflecting the growing recognition that breakthroughs in these fields demand a unified, interdisciplinary approach. The synergy between these disciplines has the potential to revolutionize our understanding of the universe's most elusive constituents.

Conclusion

In conclusion, the study of dark matter and dark energy has brought us to the forefront of our understanding of the cosmos. These mysterious components, which together make up a staggering 96% of the universes total energy budget, have challenged our fundamental principles in astrophysics, particle physics, and cosmology. The evidence supporting their existence is compelling, yet their true nature remains elusive.

The data analysis has provided the researcher with a solid basis upon which to build a more complete picture of dark energy and dark matter. It was evident from the results that respondents were still not clear about the theoretical values and believed that more efforts can be made in this field to resolve this mystery. Most respondents agreed with the concept of zero energy universe. They argued that such a universe required a tiny bit of energy to produce inflation. The universe would, therefore, experience accelerating expansion, but without creating a net energy. This section helped in understanding the viewpoint of different professionals and researchers in this field.

Dark matter, 27% of the universe, shapes galaxies and cosmic architecture. I identified candidates and gravitational evidence to infer its existence, but no dark matter particles. Both astrophysics and particle physics discover dark matter.

Dark energy controls the universe's expansion and utilizes 68% of its energy. We don't know its origins or qualities despite its significance. Problematic are the cosmic constant and changed matter theories. Quantum theory argues that space is not empty and that virtual particles form and disappear, perhaps contributing to dark energy, however there are disagreements.

Astrophysics, particle physics, and cosmology are needed to find dark matter and energy. The Large Hadron Collider and cosmological surveys show that diverse techniques are needed for cosmic puzzles.

Energy and dark matter are the universe's greatest mysteries. Their research is improving but requires more. These questions influence our understanding of space travel, extraterrestrial life, and the universe's past, present, and future. Human learning may answer the universe's terrible secrets.

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