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The comprehension of 'dark energy and dark matter'

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Abstract
An increasing body of observational data gathered over recent decades has presented substantial evidence that most of the universe consists of two "dark" elements: an enigmatic, collisionless dark matter that binds galaxies and an even more puzzling, nearly uniform dark energy component with negative isotropic pressure that causes cosmic acceleration. Collectively, these elements account for nearly 96% of the current cosmic energy budget. Dark energy accounts for approximately 74%, whereas dark matter makes up nearly 25%, rendering it six times more prevalent than visible matter. The observable matter constitutes a tiny fraction of the universe, as it accounts for roughly 4% of it. Every atom and photon in the universe constitutes under five percent of the entire contents of the cosmos. The remainder consists of dark energy and dark matter, which are unseen yet govern the universe's structure and development. Dark matter constitutes the majority of the mass within galaxies and galaxy clusters, influencing the large-scale organization of galaxies. Dark energy, on the other hand, refers to the enigmatic force causing the rapid expansion of the universe. The nature of these substances and their mechanisms pose significant challenges for contemporary astronomers.

Keywords: Dark energy, galaxies, dark matters, photon

Introduction
This study aims to examine the fundamental ideas of dark energy and dark matter. Dark matter is the unseen force that binds the universe. This enigmatic substance surrounds us, constituting the majority of the matter in the universe. What is dark matter, precisely? That's a question scientists have been attempting to answer for nearly a century.

Dark matter composes the majority of the mass in galaxies and clusters of galaxies. In reality, researchers believe that normal matter constitutes roughly 5% of the universe, while dark matter accounts for around 27%. (The remainder is believed to be dark energy, which remains a mystery in itself). Dark matter is believed to influence the universe, arranging galaxies and cosmic entities on a grand scale. Ordinary matter, which has wavelengths ranging from the infrared to visible light and gamma rays, is what we can see in the cosmos, from stars and galaxies to the shoes on your feet. Dark matter appears to have no interaction at all with the electromagnetic spectrum, which includes visible light, but it does interact with conventional matter through gravity. Therefore, no light is absorbed, reflected, or emitted by dark matter.

Despite being invisible, dark matter shares characteristics with regular matter, such as occupying space and containing mass. This allows us to "see" and study dark matter by observing its interactions and effects on conventional matter across the universe.

Dark Matter
Dutch astronomer Jan Oort and Swiss astrophysicist Fritz Zwicky separately coined the term "dark matter" to account for the inconsistencies in their individual intriguing findings. Jan Oort noted that the stars' orbital speeds in the Milky Way exceeded the predicted values, whereas Fritz found that the orbital speeds of galaxies within clusters were quicker than anticipated (Papantonopoulos, 2007, pg.35) [12]. The two astronomers referred to dark matter as the "missing mass" needed to explain this increase in speed. These findings received little attention from anyone. In the 1950s and 60s, as scientists hurried to assess the velocities of galactic rotations, they encountered a puzzling observation. They anticipated that stars close to the Milky Way galaxy's edge would move more slowly than those near the galaxy's center, according to the distribution of visible matter within the galaxy. The greater amount of visible matter gathers at the galaxy's center, so the stars close to the center were anticipated to rotate

at a higher speed. However, the Doppler effect showed that the stars located farther from the center had the same rotational speed as those near the center. During the 1970s, Vera Rubin noted the same phenomenon in multiple other galaxies (Papantonopoulos, 2007, pg.35) [12]. These observations suggested that the spiral galaxies had more mass than what was seen. Additionally, after examining spiral galaxies similar to our Milky Way, researchers noticed that our galaxy was spinning at such a velocity that it should have disassembled long ago, ejecting stars and gas in all directions. Given the visible mass, it was unfeasible for the center to stabilize; the gravity from its observable mass could not sufficiently keep the galaxy intact at such elevated rotational velocities

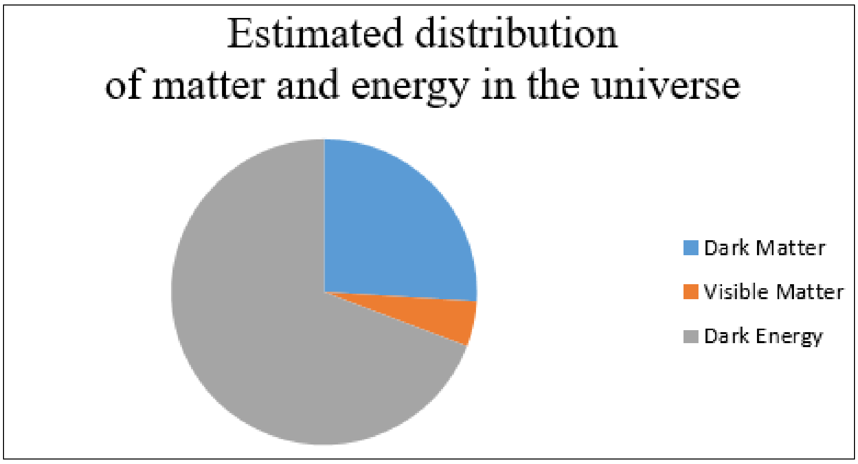

Fig 1: Normal or visible matter (5%), dark matter (27%), and dark energy (68%), comprise the cosmos.

Composition of Dark Matter: It is believed that dark matter is made up of non-baryonic WIMPs (weakly interacting massive particles), which are 10-100 times as massive as a proton yet interact weakly with conventional matter, making detection challenging. WIMPs include:

Neutralinos are hypothesized particles that are slower and heavier than neutrinos but have not yet been detected.

Since sterile neutrinos only interact with conventional matter through gravity, they are suggested as a dark matter candidate. Furthermore, particles known as neutrinos do not create ordinary matter.

Origin of Dark Matter

Galaxy rotation curves: Objects at galaxies' periphery should move more slowly than those closer to the core, in accordance with Newtonian gravity.

According to observations, stars on the fringes of galaxies move more quickly than would be predicted, indicating that dark matter - an invisible mass - provides additional gravitational attraction.

Gravitational Lensing: When light is bent by the gravity of a big object, more mass than is visible is revealed, indicating the presence of dark matter.

Theories of Dark Matter

Dark matter is a type of matter that is theorized to exist within the domains of astronomy and cosmology. Researchers understand that dark matter acts differently from ordinary matter, including planets, stars, and galaxies (this type of matter is known as baryonic matter, with atoms being its most basic unit). For example, dark matter, in contrast to normal matter, does not engage with electromagnetic energy. Therefore, it neither gives off nor takes in electromagnetic radiation at any level, making it hard to detect. Its presence is deduced solely from the gravitational influence it exerts on detectable matter (Papantonopoulos, 2007, pg.3) [12]. Dark matter is believed to constitute roughly 23% of the universe's energy density, appearing to surpass visible matter by a ratio of about five to one. Regular matter makes up roughly 4%. Computer simulations suggest that dark matter could be omnipresent; thus, as the Earth orbits the sun, it may be passing through a concentration of dark matter particles. While the majority of scientists acknowledge dark matter's existence, its true nature remains unknown. To solve this enigma, candidates for dark matter are classified into two main groups: baryonic and non-baryonic. Potential baryonic candidates being evaluated encompass Massive Compact Halo Objects (Machos). Machos are entities that constitute the halos surrounding galaxies, but they are difficult to detect due to their extremely low brightness. These objects consist of brown dwarfs, neutron stars, black holes, or simply faint stars known as white dwarfs. Besides space telescopes, gravitational lensing serves as a method for identifying the existence of Machos. Albert Einstein (1919) demonstrated that gravity alters the trajectory of light rays (gravity distorts spacetime, causing the course of any traveling radiation, including visible light, to be redirected, as a result). He forecasted that if a star positioned directly behind the sun, the sun's gravitational field would curve light rays from the star toward an observer. Due to the bending of light rays, an observer can view an image or images of the star. When a black hole travels between a galaxy or star and an observer on Earth, gravitational lensing takes place, allowing astronomers to infer the existence of a Macho. Stars in circles might also indicate the existence of a Macho. Entity like a black hole. Black holes exert a gravitational pull on nearby objects.

Therefore, when researchers observe stars orbiting an unseen entity, they infer the presence of a black hole. It seems like your message was cut off. Please provide the full text you'd like me to paraphrase, and I'll be happy to help!

In early 1995, a group of astronomers from Japan and the United States revealed the presence of a colossal a black hole that has a mass 36 million times greater than our sun. Despite the declaration being notable in its own manner, studies have not produced sufficient Machos to explain all the dark substance in the cosmos. To elucidate dark matter, particle physicists propose the presence of non-baryonic particles. Particles that infrequently engage with regular matter. The top contenders for these particles.

These particles that have not yet been found are believed to possess mass, but they engage so feebly with normal matter that they are difficult to detect. Particle physicists contend that if these particles were to interact with normal matter, measurable radiations might be released. These kinds of interactions, nonetheless, are very uncommon. Among these particles are Axions, Photinos, and Neutralinos (Papantonopoulos, 2007, pg. 36). The majority of scientists acknowledge that dark matter could consist of both baryonic MACHOs and non-baryonic WIMPs. Not every scientist acknowledges the presence of dark matter. Consequently, changes to the gravitational laws defined by Newton and elaborated by Einstein have been suggested to explain the impacts ascribed to dark matter. Among these alternative gravity theories are Modified Newtonian Dynamics (MoND) and Tensor-vector-scalar gravity (TeVeS). Some other researchers, like Dragon Hajdukovic, suggest that dark matter is a fabrication stemming from quantum physics. The identification of dark matter existence and characteristics continues to be a significant area of study in cosmology.

Dark energy

In astronomy and physical cosmology, dark energy is a hypothesized type of energy that influences the universe on vast scales. Its main impact is to propel the increasing expansion of the universe. It additionally reduces the speed of structure development. If the lambda-CDM model of cosmology is accurate, dark energy governs the universe, accounting for 68% of the total energy in the currently observable universe, whereas dark matter and ordinary (baryonic) matter account for 27% and 5%, respectively, with other components like neutrinos and photons being almost insignificant. The density of dark energy is extremely low: 7×10^{-30} g/cm^3 (6×10^{-10} J/m^3 in mass-energy), significantly lower than the density of normal matter or dark matter found in galaxies. Nonetheless, it prevails in the universe's mass-energy composition as it is consistent throughout space.

The initial observational proof of dark energy's presence arose from the analysis of supernovae. Type I supernovae exhibit a consistent luminosity, allowing them to serve as precise indicators of distance. Assessing this distance against the redshift (which indicates the velocity at which the supernova is moving away) demonstrates that the expansion of the universe is speeding up. Before this observation, scientists believed that the gravitational pull from matter and energy in the universe would lead to a gradual slowdown in the universe's expansion. Following the detection of accelerating expansion, multiple independent pieces of evidence have emerged that bolster the existence of dark energy.

There are numerous theories regarding dark energy, but its precise nature is yet unknown. The primary contenders are scalar fields, which are dynamic variables with energy densities that fluctuate in time and space, like quintessence or moduli, and cosmological constants, which represent a constant energy density uniformly filling space. While scalar fields can change throughout time and space, a cosmic constant would not. Other theories include shockwave cosmology, cosmic coupling, an observable effect, and interacting dark energy (see the section Dark energy § Theories of dark energy).

Theories of Dark Matter

According to recent measurements, dark energy has persisted throughout the history of the universe, according to Matarrese *et al*. (2011) [1]. It is unaffected by the expansion of space. It has a constant density (Luo, 2014, pg. 1). Scientists have developed a variety of theories to explain these perplexing results. The cosmological constant, which Einstein postulated in his General Relativity theory, which predicted a dynamic universe, is the most prominent explanation for dark energy. Sadly, at the time, Einstein and the majority of scientists held the view that the cosmos was static. In order to reconcile his theory with his conviction that the world was static, Einstein thus proposed a cosmological constant. Einstein proposed that the space vacuum had energy by introducing this constant. In order to prevent the universe from contracting due to gravity, this energy provided a repulsive force that neutralized all matter in the universe. Following Hubble's discovery of an expanding cosmos, the cosmological constant was later removed.

The finding of cosmic acceleration has reintroduced the cosmological constant to account for the repulsive dark energy that speeds up cosmic expansion. Certain physicists contend that the cosmological constant might represent the vacuum energy of space. For example, Chaboyer and Krauss assert that a vacuum holds non-zero energy accompanied by negative pressure. This energy is an intrinsic property of space; it remains constant even as space expands. As a result, with the universe's expansion, additional empty space emerges, leading to an increase in negative pressure in the vacuum, which drives cosmic acceleration. An alternative reason for the vacuum energy of space arises from quantum mechanics, which suggests that “emptiness in space” is filled with virtual particles that emerge from nothingness, but exist only for a brief moment (Papantonopoulos, 2007, pg.237) [12]. Certain physicists, thus, claim that the continual fleeting emergence and vanishing of these particles across the universe supplies energy that speeds up the universe's expansion. Nonetheless, when physicists evaluated this energy level against theoretical predictions and the measured value, they found a discrepancy of 120 orders of magnitude. Such extreme vacuum energy would have torn the universe apart ages ago; galaxies would not have come into existence since the universe's acceleration would have been excessively high.

Observational Hubble constant data

A novel method to assess dark energy evidence via observational Hubble constant data (OHD), referred to as cosmic chronometers, has attracted considerable interest in recent years.

The Hubble constant, H(z), is assessed as a function of cosmic redshift. OHD monitors the universe's expansion history by using passively evolving early-type galaxies as "cosmic chronometers." At this stage, this method offers standard timekeepers in the universe. The essence of this concept lies in assessing the differential age progression in relation to redshift for these cosmic chronometers. Consequently, it gives a straightforward estimation of the Hubble parameter.

$$H(z) = -\frac{1}{1+z}\frac{dz}{dt} \approx -\frac{1}{1+z}\frac{\Delta z}{\Delta t}.$$

Relying on a differential quantity, $\Delta z/\Delta t$, provides additional information and is computationally appealing: Numerous typical problems and systematic impacts can be minimized. While $\Delta z/\Delta t$ measures the Hubble parameter directly, analyses of supernovae and baryon acoustic oscillations (BAO) rely on integrals of the parameter. These factors have led to the widespread adoption of this technique to investigate dark energy features and the accelerated cosmic expansion.

Materials and Methods
The suggested approaches were effectively implemented with the help of certain data collection instruments. A questionnaire was used in the study to gather information for additional analysis.

Conclusion
The researcher has been able to identify the fundamental elements that contribute to the clarification of the ideas of dark energy and dark matter through the study of the results. The findings made it clear that respondents were still unsure about the theoretical values. The idea of a universe with zero energy was accepted by the majority of responders. They contended that inflation in such a universe would require a very small amount of energy. As a result, the cosmos would expand more quickly without producing any net energy. Understanding the perspectives of various experts and scholars in this topic was made easier by this part.

Despite making up a sizable amount of the cosmos, dark matter is still enigmatic but essential to comprehending cosmic structures and evolution. Its characteristics, origin, and impact are still being investigated by ongoing experiments and astronomical observations, which bode well for advances in basic physics.

References

1. Matarrese S, Colpi M, Gorini V, Moschella U. Dark matter and dark energy: a challenge for modern cosmology. Dordrecht: Springer; 2011.
2. Berman S. On the zero-energy universe. International Journal of Theoretical Physics. 2009;48(11):3278-3281.
3. Concepts of dark energy and dark matter: the understanding and calculation of 'dark energy and dark matter' ResearchGate. https://www.researchgate.net/publication/272302928
4. Diaz B. Proceedings of the International Conference of Computing Anticipatory Systems. American Institute of Physics; 2003.
5. Huterer D. Growth of cosmic structure. The Astronomy and Astrophysics Review. 2023;31(1):2-44. DOI:10.1007/s00159-023-00147-4
6. Ade PAR, Aghanim N, Alves MIR, et al. Planck 2013 results. I. Overview of products and scientific results - Table 9. Astronomy and Astrophysics. 2014;571:A1. DOI:10.1051/0004-6361/201321529
7. Marcondes RJF. Interacting dark energy models in cosmology and large-scale structure observational tests. arXiv. 2016. arXiv:1610.01272
8. Carroll S. Dark matter, dark energy: the dark side of the universe. Caltech: The Teaching Company; 2007. p. 46.
9. Dark energy and dark matter. Harvard-Smithsonian Center for Astrophysics. https://www.cfa.harvard.edu/research/topic/dark-energy-and-dark-matter
10. Dark matter and dark energy. Drishti IAS. https://www.drishtiias.com/daily-updates/daily-news-analysis/dark-matter-and-dark-energy-1
11. Zikmund WG. Business research methods. Ohio: Thomson South Western; 2003.
12. Mylonakis G, Kloukinas P, Papantonopoulos C. An alternative to the Mononobe-Okabe equations for seismic earth pressures. Soil Dynamics and Earthquake Engineering. 2007 Oct 1;27(10):957-969.