Framework for Energy Manifestations in the Universe's Mass-Energy Composition:

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November 3, 2024

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01-11-2024

Abstract:

This study explores the total mass-energy content of the universe, revealing that approximately 5% comprises baryonic matter, while the remaining 95% consists of dark energy and dark matter. Dark energy, a major constituent, is characterized by a unique property of negative pressure, driving the accelerated expansion of the universe. This work delves into the intricate relationships among mass components—baryonic matter, dark matter, and dark energy—and examines their influence on gravitational dynamics, effective mass, and energy distribution across cosmic structures.

Keywords: Mass-Energy Composition, Dark Energy, Dark Matter, Baryonic Matter, Cosmic Dynamics, Effective Mass, Apparent Mass, Gravitational Interactions, Extended Classical Mechanics, Kinetic Energy, Potential Energy, Cosmic Expansion, Gravitational Stability, Energy Manifestations, Cosmological Principle, Negative Pressure, Mass Distribution, Gravitating Mass, Newtonian Mechanics,

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Funding: No specific funding was received for this work.

Potential competing interests: No potential competing interests to declare.

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1. Introduction:

The universe's mass-energy distribution is dominated by non-baryonic components, with dark energy and dark matter representing the bulk of its constituents. While dark energy accelerates cosmic expansion, dark matter contributes to the formation and stability of galaxies and clusters. This study provides an in-depth analysis of these components through an extended classical mechanics approach, highlighting key mass-energy interactions and their implications on the dynamics of large-scale structures.

2. Mass-Energy Constituents and Dark Energy in Cosmic Dynamics:

2.1 Baryonic Matter and Dark Energy Contributions:

Baryonic matter, making up only about 5% of the universe's mass-energy content, is dwarfed by the contributions of dark energy and dark matter. Dark energy, exerting negative pressure, acts as an antigravitational force driving galactic recession and cosmic expansion.

2.2 Case Study: Coma Cluster Dynamics under Dark Energy Influence:

In "*Dark Energy and the Structure of the Coma Cluster of Galaxies*" by A. D. Chernin et al., researchers apply Newtonian mechanics to understand dark energy's role in the dynamics of the Coma Cluster. This analysis reveals that dark energy's antigravitational force counteracts gravitational attraction, stabilizing the cluster and preventing collapse. The study redefines the gravitational influence by relating gravitating mass (M_G) to matter and effective mass, diverging from spacetime curvature interpretations in general relativity.

3. Mass Components in Extended Classical Mechanics:

The relationship among gravitating mass, matter mass, and effective mass provides a new perspective on gravitational interactions and dark energy influence. This is formalized as:

$$M_G = M_M + M^{eff}$$

Where:

M_G: Total gravitating mass, including both matter and effective mass contributions.

M_M: Matter mass, encompassing both baryonic and dark matter contributions.

M^{eff}: Effective mass representing dark energy's influence and any additional mass phenomena that alter gravitational dynamics.

This formulation integrates gravitational effects and dark energy, providing a robust framework for analysing gravitational interactions.

4. Apparent and Effective Mass Contributions:

4.1 Apparent Mass Dynamics:
Apparent mass within extended classical mechanics modifies Newton's equation of motion as:

$$F = (M_M - M^{app})\cdot a^{eff}$$

Where M^{eff} is the effective mass, combining matter mass M_M and apparent mass M^{app} contributions − which is negative. This reinterpretation leads to an adjusted gravitational potential, incorporating effective mass terms to account for dark energy influences, when when $M^{app} > M_M$.

4.2 Effective Mass in Gravitationally Bound Systems:
For systems like galaxy clusters, gravitational dynamics are influenced by matter mass (M_M) and negative apparent mass ($-M^{app}$). Here, total effective mass (M^{eff}) includes dark matter, baryonic matter, and apparent mass, expressed as:

$$M_G = M_{ORD} + M_{DM} + (-M^{app})$$

Where:
- M_{ORD}: Ordinary baryonic matter.
- M_{DM}: Dark matter mass.
- $-M^{app}$: Negative apparent mass from effective acceleration.

5. Uniform Matter Density and Cosmological Homogeneity:

The matter-energy distribution is uniformly dense on cosmological scales, with dark energy maintaining a constant energy density. The cosmological principle posits that, on large scales, the universe is isotropic and homogeneous. This framework supports the uniform distribution of galaxies, clustered in structures spanning millions of light-years.

The matter density, including both dark and baryonic components, is expressed as:

$$\rho_M = M_{M,total}/V$$

Where ρ_M represents the matter density per unit volume.

6. Total Energy of the Observable Universe:

The universe’s total energy is defined as:

$$E_{total,Univ} = PE_{MM,Univ} + KE_{MM,Univ}$$

Where:
- $PE_{MM,Univ}$: Potential energy from gravitational and other cosmic fields within mass-energy manifestations.
- $KE_{MM,Univ}$: Kinetic energy resulting from effective mass motion, possibly influenced by dark energy transformations.

In this framework, KE_{MM} embodies transformations linked to apparent mass and effective mass contributions, suggesting that it serves as a representation of dark energy in the extended mechanics framework. This interpretation proposes that total energy consists of potential energy PE_{MM} and kinetic energy KE_{MM}, emphasizing the dynamic interplay between these forms and their contributions to cosmic structure and expansion.

This framework treats total energy as a balance between potential and kinetic energies, with potential energy representing latent cosmic field effects and kinetic energy incorporating dynamic mass-energy interactions across the universe.

This framework also emphasizes the integration of kinetic and potential energies while suggesting that rest energy, as traditionally defined in relativity, may not be essential in understanding the broader context of energy manifestations in the universe's mass-energy composition.

7. Discussion

The study titled "The Mass-Energy Composition of the Observable Universe: Part 1 - A Framework for Potential and Kinetic Energy Manifestations" offers a nuanced look at the universe’s mass-energy components, where dark matter and dark energy substantially outweigh baryonic matter. This work deepens our understanding of the cosmos by proposing an extended classical mechanics framework that treats dark energy, dark matter, and effective mass as key constituents influencing cosmic structure and expansion.

Central to the study’s analysis is the concept of effective mass, which combines matter mass and apparent mass contributions. By defining effective mass as a sum of positive and negative mass effects, the study introduces a paradigm in which dark energy’s negative apparent mass serves as an antigravitational force that counters gravitational collapse, thereby supporting cosmic expansion. This innovative interpretation challenges conventional spacetime curvature models within general relativity, suggesting instead that mass-energy interactions can be understood through classical mechanics extended to account for dark energy effects.

A particularly insightful aspect of this study is its use of the Coma Cluster as a case study. Drawing on Chernin et al.'s work, it examines how dark energy exerts an antigravitational effect that stabilizes the cluster. The analysis indicates that dark energy plays a pivotal role in maintaining large-scale structure, as its influence manifests as a negative apparent mass ($-M^{app}$), which adds to the cluster's overall effective mass. This reinterpretation provides an alternative to the dark matter-centric view of galactic dynamics by attributing part of the gravitational stability to dark energy's influence on mass distribution.

Additionally, the study delves into gravitational dynamics through equations where apparent mass alters the traditional force equation,

$$F = (M_M - M^{app})\cdot a^{eff}.$$

Here, apparent mass is posited as a variable that offsets ordinary matter mass under certain conditions (when $M^{app} > M_M$).

This framework allows for a refined approach to gravitational potential in systems where dark energy and dark matter are dominant. Through these equations, the study provides a structured method for calculating total gravitating mass as a sum of ordinary matter, dark matter, and effective mass components, addressing the distinct yet interconnected roles of these masses in large-scale structures.

The study also emphasizes the cosmological principle of homogeneity and isotropy on cosmic scales, which supports the assumption that dark energy density remains constant throughout the universe. This uniformity of mass-energy distribution underscores the concept that, while dark energy is responsible for cosmic acceleration, it does so without disrupting the overall homogeneity of matter density.

In summary, the study presents a coherent model that integrates potential and kinetic energy manifestations of mass components, redefining how dark energy and dark matter contribute to cosmic expansion and stability. By extending classical mechanics to account for dark energy's negative pressure, it suggests a viable alternative to the relativistic interpretation of gravitational dynamics. This model has implications for the future study of galaxy formation, cluster dynamics, and the ultimate fate of the universe, highlighting the necessity of viewing mass-energy as an intricate blend of baryonic, dark, and effective masses in an evolving cosmic landscape.

8. Conclusion:

This study presents a structured approach to understanding the universe's mass-energy composition, emphasizing the integration of dark matter, dark energy, and effective mass in cosmic dynamics. By redefining mass interactions within an extended classical framework, this approach highlights the dynamic role of potential and kinetic energies in shaping cosmic structure and evolution. The distinctions between effective and apparent mass provide further insight into the forces governing the universe's large-scale motion and structure.

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