Negative Energy in Physical Model of Cosmic Origin and Expansion

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Abstract

Cosmological evidence and evidence from gravitational energies demonstrate negative energy in space and a fundamental positive-negative symmetry of energy. New physics for cosmic expansion and origin emerge from one principle. In the new Dual-Energy Cosmological model a universe of positive energy arises naturally from zero in a 'not quite so big' bang with corresponding negative energy. An initial singularity is naturally avoided. Spatial flatness, isotropy emerge naturally. Expansion is driven by repulsive gravitational forces between massive clusters and surrounding voids dominated by negative energy. 'Dark energy' is found to be an effect of negative energy in space. It evolves dynamically with continued gravitational collapse/mass aggregation. Negative energy is the ultimate energy source in gravity. An older universe and slower expansion in the young universe are testable predictions. An anti-de Sitter character of 'empty space' may support AdS/CFT correspondence. Fundamental energy concepts in other areas of physics may be reconsidered.

Keywords

Cosmology, dark energy, cosmological model, gravitation, dark matter

1 The suggestion of a fundamental role of negative energy

1.1 Introduction

There is something big missing in current understanding of cosmology. The current Lambda-CDM model assumes a universe of various forms of positive energy only. General relativity in its current form requires the assumption of a custom defined presence of dark energy and dark matter in order to explain the observed cosmological behavior of the universe. These are supposed to make up some 95% of the energy content of the universe with shares of 27% (dark matter) and 68% (dark energy). No proof for neither dark matter nor dark energy have been confirmed other than the gravitational effect which their assumed presence is designed to explain. Particularly troubling is the approach to address the repulsion in the expanding universe with dark energy, a hypothetical type of positive energy. Dark energy's suggested repulsive effects depend on the arbitrary assignment of negative pressure. The repulsive effect is contrary to the attractive gravitational effect from positive mass-energy, but is in line with the repulsive gravitational effects to be naturally expected from negative mass-energy. The fundamental problem in understanding the repulsive dynamic nature of our universe has become increasingly obvious in mounting evidence that the expansion of the universe is accelerating. This acceleration points to an unexplained increase of the unexplained dark energy over time. How can positive energy emerge without a positive energy source? In the current 'single-energy' understanding of a world of positive energy only, the mass-energy in the universe has arisen in a chance event at the beginning of the big bang. There is no known mechanism for generation of additional energy and any proposals would require a violation of symmetry. Efforts to model the dynamics of the expanding universe have focused on deliberate quantitative additions and correction such as the cosmological constant, more attractive dark matter and the presence of dark energy. However, an unexplained quantitative 'tension' has persisted in the assessment of the Hubble constant based on current interpretation of Cosmic Microwave Background (CMB) data and the more direct assessment of expansion based on observations of the later universe. Evidence is presented that beyond quantitative inconsistencies cosmology is confronted with a deeply fundamental issue that has been obstructing the understanding of questions of both expansion and origin of the universe. The missing link in physical understanding relates to the phenomenon of energy. Evidence from key cosmological features as well as specific evidence in gravity is presented which coherently suggests the presence of negative energy in space and a fundamental positive-negative symmetry of energy. It leads to a new cosmological model based on new dual-energy[1] physics.

1.2 Structure of the evidence

The dual-energy principle is evidenced on multiple levels in nature, from its widespread cosmological impact to its role in gravity. The complexity calls for guidance on the structure of the evidence: The dual-energy principle is shown to naturally address a comprehensive range of seemingly unrelated key cosmological questions of cosmic expansion and origin of energy. It naturally delivers bottom-up physical definition where current theory requires deliberate top-down adjustments and an array of additional assumptions. The dual-energy principle naturally avoids an initial singularity and other hard fundamental problems in current theory. A higher order of symmetric structure in the evolution of the universe emerges. An independent direct proof for the dual-energy principle is demonstrated from an

[1]'Dual-energy' denotes the suggested fundamental positive-negative nature of the phenomenon of energy.' Single-energy' is used to reference theories and models based on a universe of positive mass-energy only.

assessment of the physicality of energies in gravity. The new theory also leads to the testable prediction of an age of the universe significantly older than the currently assumed 13.77 ± 0.06 billion years[2]. The evidence for the dual-energy principle is derived from outside the framework of general relativity and reveals an incomplete representation of energy in current general relativity.

1.3 Dual-Energy principle key to both expansion and origin

The dual-energy principle directly provides physical definition for two fundamental concepts in cosmology: The expansion of the universe and how a universe of energy arises from zero. In both general relativity and Newtonian dynamics negative mass-energy is naturally associated with a repulsive gravitational effect on positive masses. Under Newton's law of universal gravitation, the attractive gravitational force reverses when one of the masses considered is negative. Under general relativity they emerge as the presence of negative energy contributes to negative curvature of spacetime. The mechanism of generation of positive energy along with negative energy in gravity demonstrates an ultimate source for energy in the universe. It addresses how energy for an accelerated cosmic expansion emerges in the current universe and it demonstrates a fundamental physical process for energy arising in a 'not quite so big' bang from a state of zero energy along with corresponding negative energy.

1.4 Specific elements of evidence

The specific elements of evidence for the dual-energy principle include:
- evidence for the lack of a positive physical energy source for gravity
- evidence for the presence of negative energy in space from its repulsive effects observable in cosmic expansion
- presentation of a mechanism for the generation of negative energy in the current universe
- the ability to naturally and coherently address a sweeping range of major unresolved issues in current cosmology
- being able to do so from one physical principle and by
- revealing a systemic insufficiency of single-energy theory for addressing origin, energy content and the repulsive dynamics of an expanding flat universe.

1.5 An independent pathway from energy in gravity

The dual-energy principle can be independently proved from an evaluation of the physical energy source for gravity. Fundamental characteristics of physical energy have long been established. They include that states of energy have determinable values and that the presence of physical energy is a source for gravitational effects. Gravitational potential energy lacks these characteristics. No value is determinable as there are no definable limits for further gravitational mass aggregation for any mass in the universe. The abstract concept of gravitational potential energy has no inherent suggestion for the localization of energy with gravitational effects. A positive energy source for gravity in the gravitational field can be excluded as the field only emerges and increases subsequent to energy being delivered in gravitational accretion. By contrast, the negative energy resulting from gravity is directly determinable as the negative equivalent of the energy gained in gravitational acceleration. It also is a source for repulsive gravitational effects as it contributes to cosmic expansion. Gravitational potential energy is found to be a mathematical placeholder for what physically is an exchange with negative energy of space.

[2] Detailed in 2.4.

1.6 Direct solutions from one principle versus standard model

The realization of the dual-energy principle and the presence of negative energy in space sweepingly and directly address fundamental problems in current cosmology. Full details and the long list of current problems addressed are presented in 2. The dual-energy principle naturally delivers a bottom-up physical model of both cosmic expansion and origin of a flat universe. Expansion is driven by the repulsive gravitational effects between clusters of positive mass-energy and surrounding voids dominated by negative energy. These repulsive forces naturally define direction in expansion. The current Lambda-CDM standard model lacks definition for the fundamental physical cause for expansion. It assumes a kinetic model of accelerated positive masses in expansion. It lacks definition for a physical mechanism for the implied initial acceleration and also lacks a physical model for the 'dark energy' responsible for an accelerated expansion. It further cannot define direction for expansion as directions of accelerated masses populating 3D space would need to point towards others. They cannot all point away from each other.

The dual-energy principle also provides a fundamental physical process for the origin of our universe of energy. Positive energy emerges along with corresponding negative energy from a state of zero energy in a not quite so big bang in a process fundamentally equivalent to what we observe in modern gravity. The process of something arising from 'nothing' is as comprehensible as the illustrative term 0 = -1 +1. It provides a unique symmetrical solution for the fundamental problem of origin of energy. Under current single-energy theory the fundamental physics of origin of energy are unknown if not unknowable. The discovery of the expansion of the universe has been suggesting a moment of beginning of the universe. As the positive energy must have come into existence somehow, the standard model assumes a random fluctuation as its cause, in analogy to quantum behavior. The model leads to an unphysical singularity of positive energy that expands contrary to known laws of physics.

The current concept of a random fluctuation does not naturally explain the formation of structure in the universe. The observation of homogenous repetitive clusters across the horizon is the opposite of what is to be expected from a random fluctuation. Current theory therefore relies on additional assumptions under inflation theory. Under the dual-energy principle energy emerges in uniform mechanisms across and beyond the observable universe rather than a random fluctuation. Repetitive homogenous structures emerge as a natural consequence. No horizon problem arises as causal contact is not required to result in an isotropic universe. Current theory further requires incredibly fine-tuned initial energy conditions to explain the observed spatial flatness of the universe. As no physical mechanism for these energy conditions is provided it leaves the assumption of an unexplained chance event. Under the dual-energy principle flatness emerges naturally as the universe emerges with corresponding amounts of positive and negative energy.

The new theory delivers physical solutions for a sweeping range of cosmological questions from one principle where the current standard model lacks physical definition and/or requires additional individual concepts to fix issues arising naturally under the single-energy model. Hard contradictions with known laws of physics still remain in the standard model as an initial singularity and subsequent ultra-dense states of positive energy should be held together by overwhelming gravity, not expand. For lack of a fundamental alternative that provides coherent solutions shortcomings in single-energy theory have been tolerated or worked around with additional assumptions. Yet, for almost a century after the discovery of cosmic expansion a fundamental gap has persisted. These systemic deficiencies now emerge as demonstrable evidence for the insufficiency of single-energy theory for the origin and expansion of the universe.

1.7 Outline of the Dual-Energy Cosmological model

A qualitative outline of a new Dual-Energy Cosmological (DEC) model emerges. The universe consists of both positive and negative energies. Expansion is caused by repulsive gravitational forces. Effects that have been attributed to dark energy or a cosmological constant are effects of negative energy. Negative energy acts as a dynamically evolving property of space. Continued gravitational aggregation/collapse particularly in the most energetic growth of black holes increases negative energy in space. The presumed dark matter presence is indirectly affected: Repulsive gravitational effects pushing in on massive clusters from surrounding areas of space dominated by negative energy project as more attractive matter in single-energy models. Remaining requirements for dark matter presence are to be determined. The Lambda-CDM model becomes obsolete. Positive energy emerges along with corresponding negative energy from zero in a not quite so big bang. Isotropy and repetitive homogenous structures emerge naturally as the emergence of energy follows uniform mechanisms. Positive and corresponding negative energies naturally deliver a spatially flat universe. The universe is expected to be significantly older than the currently assumed 13.77 billion years.

1.8 New symmetry, unfolding foundational questions

The dual-energy principle has unfolding foundational implications. It demonstrates a higher order of symmetry reflected in the evolution of our universe than current theory assumes. Beyond current understanding that matter arises from positive energy together with corresponding anti-matter, positive energy emerges together with a negative counterpart. The dual-energy mechanism is a surprising unitary cause behind both origin and expansion. The force of gravity is found to include repulsive effects corresponding with other forces of nature. It is found not to transfer energy but to generate it. It is the fundamental mechanism at the very beginning that generates a universe of energy. The dual-energy principle suggests a path to redefine or complement fundamental energy concepts in quantum physics/particle physics to where positive energies ultimately are matched by corresponding negative energy[3]. The realization of negative energy in space has another surprising implication. It points to an anti-de Sitter like character of ‘empty space’ and a basis for the real-world relevance[4] of the approach of string theory in AdS/CFT correspondence first proposed by Maldacena [1].

The physical properties of this strange new world of negative energy may reveal further foundational insights. Under DEC negative energy is a real physical entity with properties to be explored, rather than a mere mathematical feature[5]. The question arises whether negative energy spreads as a local or nonlocal effect. At this point a nonlocal character is not excluded[6].

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[3] This suggestion is detailed in 7.

[4] A negatively curved ‘anti-de Sitter’ universe has been a crucial but seemingly missing precondition for Ads/CFT correspondence.

[5] Unlike a mathematical concept of negative gravitational potential energy which may be employed without fundamental physical implications.

[6] This is detailed in 5.

1.9 Earlier considerations of negative mass and energy

Notable suggestions for negative mass and negative energy have been made before in cosmology and quantum field theory. Examples include Einstein who reportedly had considered a repulsive gravitational effect from negative masses earlier in the development of general relativity. More recently Farnes [2] has suggested that continuous matter creation of a dark fluid with negative mass may address both dark energy and dark matter. Cosmological negative energy has been introduced by Guth [3] in inflation theory. Negative energy densities have been employed in the context of vacuum fluctuations in quantum field theory by Ford [4]. Gravitational energies are often assumed to have a negative character which has led to suggestions of a 'zero-energy' universe which include an early suggestion by Tryon [5], and publications by Vilenkin [6], Hawking [7] and Krauss [8]. However, no wider cosmological concept has evolved.

2 Specific solutions under DEC for problems in current standard model

2.1 Problems arising from incomplete representation of energy in current theory

Fundamental cosmological problems and inconsistencies arising under current single-energy theory have been addressed by adaptations in general relativity and other isolated conceptual proposals. Dual-energy theory introduces a new theoretical understanding of energy and gravity which redefines cosmological concepts of origin and expansion. On the basis of the new theory various inconsistencies in current theory can be identified as artifacts of the single-energy model, gaps in physical understanding can be filled. A systemic 'energy problem' in the standard Lambda-CDM model becomes discernable. While the dual-energy principle leads to an entirely new concept the nomenclature used here is centered on current theory for easier reference. The list of issues affected by the energy problem includes but is not limited to: An initial quantum fluctuation for the origin of energy, an initial singularity, isotropy from a presumed random fluctuation, the horizon problem, homogenous repetitive structures in the universe, spatial flatness of the universe, definition of forces and energies causing expansion, determination of direction in cosmic expansion, cosmological constant, surprising maturity of galaxies at high red shift, dark energy, dark matter (indirectly), the tension in determination of Hubble constant between CMB based model and observation of the later universe, unrealistically inflated expected value for the vacuum energy of space from zero-point point fluctuations, lack of understanding of dominant energies in the Lambda-CDM model. The new theory addresses all of these issues from one principle and this is how:

2.2 Something from nothing, initial singularity or not quite so big bang, emergence of structure

The fundamental question of how our world of matter and other forms of energy arises from 'nothing', physically a state of zero energy, has been notoriously hard to grasp for science and human comprehension. Both our experience of the world and its scientific exploration have been trained on objects of positive energy only and energy seems to be always conserved. Negative energy is easily overlooked as it spreads thinly across space and repulsive gravitational effects prevail only on large cosmological scales. As we observe that energy is conserved, we conclude that everything must come from something, nothing comes from nothing. This fundamental conundrum persists only as long as negative energy is not considered. With the realization of negative energy, the basic principle for generation of energy from zero becomes as transparent as the illustrative term 0 = -1 +1. This is how the issue of origin from a state of zero energy evolves under DEC and how it compares to current theory:

In the dual-energy model positive energy arises naturally along with corresponding amounts of negative energy from zero in a 'not quite so big' bang. The positive and negative energies always add up to a value of zero: $E_{pos} + E_{neg} = 0$. Changes follow $\Delta E_{neg} = -\Delta E_{pos}$. It is the fundamentally equivalent process that can be shown at work in gravity in the current universe. It follows a continuous mathematical concept. It is the unique path for an origin of energy that observes a universal symmetry. This quality is a unique hallmark for the dual-energy principle. The model leaves no need to resort to a random fluctuation to deliver initial positive energy. Isotropy and repetitive homogenous structures in the universe emerge naturally as the early emergence of energy follows uniform mechanisms across and beyond the horizon rather than a random initial fluctuation. There is no horizon problem as causal contact between remote areas of space is not required for isotropy. The need to assume inflation does not arise. The question of how positive-negative energy specifically unfolds in the very beginning of a not quite so big bang opens the door for new dual-energy physics. It may be determined by dual-energy approaches to fundamental energy concepts in other areas of physics, such as quantum field theory, string theory and potentially other novel approaches. This is further detailed in 7.

Single-energy models trace the expansion of the universe back to an 'unphysical' initial singularity of positive energy. Singularities indicate artificial results of math rather than valid physical descriptions. The single-energy model requires the assumption of a chance fluctuation event delivering the positive energy for an initial singularity. While it points to an analogy with quantum behavior[7], the physics for this proposed chance event remain speculative. The emergence of cosmic structure is another problem for the current model. Observations of the universe demonstrate isotropy with homogenous repetitive structures in massive clusters across the horizon. This is in fundamental opposition to what is to be expected from a random fluctuation. Additional assumptions of inflation are required to address this fundamental problem. The single-energy model also leads to a direct conflict with known laws of physics that cannot be solved under single-energy general relativity: The initial singularity, as well as subsequent ultra-dense states should be held together by overwhelming gravity, not expand. The DEC model, by contrast, inherently delivers the repulsive forces between the emerging speckles dominated by positive and negative energy. The initial singularity is an artifact of single-energy models. The new understanding of fundamental dynamics in the evolution of cosmic structure calls for the reevaluation of current interpretations of CMB data. It suggests that the current tension in the assessment of the Hubble constant based on CMB data and observation of the later universe emerges as the consequence of invalid assumptions on the CMB. By relying on positive energy only, models for the origin of energy require rather speculative proposals beyond known physics. The new theory brings the question of origin naturally within the reach of known and knowable physics.

2.3 Flatness of the universe

Current theory struggles to explain the observed spatial flatness of the universe on cosmological scales. Under the current model this requires fine-tuned initial energy densities to result in the observed

[7] The analogy is questionable. The concept of positive energy only from zero-point quantum fluctuations is in staggering conflict with realistic values for the vacuum energy of space, see 2.7. A suggestion for negative energy in quantum fluctuations has been made by Ford [4].

flatness. Lacking the identification of a physical principle responsible for the observed flatness, single-energy theory is left to assume initial chance events of unknown physics as its cause. Under DEC positive energy emerges along with corresponding negative energy. Local areas dominated by positive or negative curvature even out on cosmological scales. It naturally delivers the positive and negative curvatures for a spatially flat universe. The observed flatness of the universe is a hallmark for and the necessary consequence of a universal dual-energy principle of nature.

2.4 The fundamental physical model for cosmic expansion and a testable prediction

This subsection relates to the issues of the physical cause for cosmic expansion, the hard problem of direction, the cosmological constant, the age of the universe and the observation of surprisingly mature galaxies at high red shifts. The current single-energy physical world view implies a universe of attractive positive masses only. This is in fundamental conflict with observations of our universe on cosmological scales, which throughout its history has displayed repulsive behavior. Single-energy theory does not clearly identify the nature of the repulsive forces driving cosmic expansion throughout its history. Expansion is not modeled by general relativity alone. It requires the additional Friedmann equations which adopt a kinetic concept. The model assumes that expansion is driven by the inertia of positive masses. It implies an unidentified initial acceleration event in the big bang which is since slowed by attractive gravity and accelerated by negative pressure from 'dark energy'. Under the new theory the physical cause for cosmic expansion is naturally defined. It is caused by the repulsive gravitational effects between clusters of positive mass-energy and surrounding voids dominated by negative energy. The repulsive gravitational force already follows from Newton's law of universal gravitation,

$$F = G\frac{m_1 m_2}{r^2},$$

where F is the gravitational force, G the gravitational constant, m_1 and m_2 the masses considered and r their distance. The attractive gravitational force reverses when one of the masses considered is negative. Under general relativity negative energy also is associated with repulsive gravitational effects as a presence of negative energy contributes to negative curvature of spacetime.

The current model of expansion lacks physical definition not only for the fundamental cause of cosmic expansion but also for its direction. The directions of initial acceleration as well as the directions for the kinetic momentum of positive masses populating 3D space would need to point towards others, they cannot all point away from each other. The current concept does not provide a sensical physical model for expansion. Under the new theory direction is readily defined by the repulsive gravitational effects between clusters of positive mass-energy and surrounding voids dominated by negative energy. The resulting dynamic pattern is consistent with cosmological observation, where massive clusters largely remain in their primordial place with space between adjacent clusters expanding. The ability to naturally define direction in expansion is a hallmark for the dual-energy principle and exposes a systemic insufficiency of single-energy models.

Single-energy based general relativity has been able to produce impressively precise and novel predictions on a significant range of astronomical scales. However, cosmic expansion has not been predicted and no type of energy responsible for it has been understood. A universe consisting of positive mass-energy only should have never expanded. Any expansion should slow down, not accelerate. As the universe does the opposite, corrective adaptations have been made. A cosmological constant has been added to the mathematical model of general relativity. A more physical approach is the assumption of the presence of a hypothetical type of positive energy termed dark energy. Under DEC no need for a cosmological constant is expected as the physical cause for expansion is identified. It is the presence of negative energy. The origin and evolution of negative energy is described by the emerging dual-energy model. Negative energy in space evolves dynamically from an early onset in a not quite so big bang along with the emergence of positive mass-energy.

Under the new theory, the model of a kinetically driven expansion described by the Friedmann equations is invalid. The new model is fundamentally a force driven model of expansion, where the Hubble parameter varies with the opposing positive and negative energy densities. This invalidates current estimates for the age of the universe. The expected scenario under dual-energy theory looks like this: Rapid expansion from an early onset of energy and matter generation slows to near halt with energy densities diluting in expansion. In a subsequent era of gravitational matter aggregation/collapse in clouds, black holes, stars and galaxies the expansion gradually resumes as new positive-negative energies are generated. The elapse of cosmic times in the dark ages and through an early phase of formation of the oldest stars and galaxies is expected to be much longer than currently assumed. It allows for longer cosmic times for pre-galactic structures and the first galaxies to form. The need for excessive dark matter assumptions vanishes. A much older age of the universe addresses the observation of galaxies with surprising maturity at high redshifts as observed in an ALPINE-ALMA survey [9]. It also allows for stars older than the currently assumed age of the universe of around 13.77 billion years. Astrophysical considerations have long pointed to the presence of stars older than 13.77 billion years. However, the high level of confidence in the current model of expansion has put modeling assumptions into focus that allow for the possibility of a younger age for these stars. An assessment of the age of nearby star HD 140283 by Bond et. al. (2013) resulted in 14.46 billion years with an uncertainty of ± 0.8 billion years [10].

The new theory leads to the testable prediction that the age of the universe is much older than values assumed under the current model of expansion. At this stage no upper limit is determinable. The prediction is based on the expectation of an extended era of much slower expansion in the dark ages and the early phases of the gravitational evolution of first galaxies, black holes and stars. A signature for this may be detected from the observation and analysis of the following elements and/or a combination of these: i) Luminosity distance to redshift relationship of high redshift objects, ii) astrophysical age determination of objects observed at any redshift, iii) modeling of time requirement for evolution from smooth energy distribution in CMB to first observable galaxies.

The predicted divergence in the luminosity distance to redshift relationship is most significant at highest redshifts. These objects are farther away, their light older and appearing fainter than their redshift suggests under the current model of expansion. The exciting opportunity for an observational confirmation of the new dual-energy physics will be greatly enhanced with the soon to be launched James Webb Space Telescope. As the kinetic model of expansion described by the Friedmann equations falls away and expansion parameters instead depend on actual dynamically evolving processes, the observation of the early universe becomes even more crucial to explore the history of our universe and eventually determine its age. A future 'Ultimately Large Telescope' may lead to direct detection of the first Population III stars as recently proposed by Schauer, Drory and Bromm [11]. Such a facility should be able to provide unique detail on the early quantitative evolution of the Hubble parameter and on the early formation of structure.

2.5 Dark energy, acceleration of cosmic expansion

The observation of an accelerated cosmic expansion presents a two-fold fundamental challenge to current single-energy theory. It points to the presence of an unknown repulsive type of energy which is increasing for no known physical reason. This has led to the assumption of the presence of a hypothetical form of positive energy with repulsive effects due to the deliberate assignment of negative pressure. Still, no mechanism for the generation of this dark energy is known and its atypical nature remains speculative. As single-energy theory treats positive energy as a given quantity from a chance event at the beginning of a big bang, energy arising without a positive source appears particularly mysterious. The lack of physical understanding of a dominating part of our universe has raised expectations of new physics.

Dual-energy theory naturally solves both mysteries as it demonstrates both repulsive gravity and the increase in energies. Under the new theory the form of energy in space that exerts repulsive effects is negative energy. Negative energy acts as a dynamically evolving property of space. As gravitational aggregation/collapse progresses negative energy increases along with positive energy. The dynamic increase contributes to an acceleration of expansion. A significant contributor is expected from energies involved in the growth and merger of the most compactified heavy objects, particularly black holes. The potential for a new type of cosmological assessment for the evolution of negative energy over time is detailed in 4. As dual-energy theory delivers new physics it demonstrates that the mystery about dark energy marked only the tip of the iceberg of a highly consequential fundamental gap in the understanding of the phenomenon of energy.

The dark energy problem is a hallmark for the dual-energy principle. The concept of mysteriously arising positive energy that acts like negative energy is shown to be an artificial addition to fix a more fundamental problem in single-energy theory. While the concept of dark energy is contrived, the dual-energy solution is direct and natural. Accelerated cosmic expansion is only one issue in a wider context of problems naturally addressed by the same dual-energy principle. Dual-energy theory therefore presents physics with a clear-cut fundamental alternative to current single-energy theory. Each of the individual issues where single-energy is demonstrated to be systemically unfit reflects on the validity of the fundamental single-energy concept. Stunningly, the effects of negative energy in space have long been discovered, ultimately since Hubble's discovery of the expansion of the universe in the 1920's.

2.6 Dark matter

The new theory also has an impact on predictions of the presence of dark matter in space. Galaxies and other massive astronomical clusters have been observed rotating too fast to be held together by the masses of their ordinary matter under the current single-energy model of general relativity. The leading approach to account for the difference under single-energy models is the assumption of the presence of more attractive matter of an unknown invisible type in the outer regions of the clusters. A suggestion for an effect of negative mass has already been made by Farnes [2]. The current standard model assumes dark matter to be the dominant form of matter in the universe. However, no effects other than the gravitational effect ascribed to the projected dark matter have been identified and its nature has remained elusive.

Under DEC the repulsive gravitational forces pushing in from surrounding areas of space dominated by negative energy are to be considered. The repulsive gravitational effect from surrounding space dominated by negative energy may project as an effect of more attractive mass further inside in single-energy based modeling. The assumed yet unidentified dark matter may be impacted by a flawed projection. New dual-energy based modeling may redefine remaining requirements for dark matter.

2.7 Vacuum energy of space from zero-point quantum fluctuations

Single-energy based models in quantum field theory have resulted in unrealistically inflated expected values for the vacuum energy of space from zero-point quantum fluctuations. These results bear no relation with cosmological observation. Under the fundamental suggestion from the dual-energy principle any emerging positive energy is naturally matched by corresponding negative energy. Negative energy densities in vacuum fluctuations have been considered by Ford [4]. The unrealistic results from single-energy based models demonstrate that fundamental energy concepts in quantum field theory are affected by the energy problem. It confirms a need for the development of dual-energy based concepts in quantum physics. The new theory suggests that the exceedingly unrealistic expectation of a positive value is an artifact of single-energy models.

2.8 Energy content under Lambda-CDM model

The realization of the dual-energy principle identifies fundamental energies and renders the current understanding of the energy content of the universe under the legacy Lambda-CDM model obsolete. New quantitative dual-energy models are to be developed. Under the emerging DEC model, the universe is expected to have negative energy matching its total positive energy. It has no positive dark energy. Its dark matter content is to be reevaluated, relative shares of forms of positive energy are to be redetermined.

3 Proof for dual-energy principle in gravity

3.1 The down to earth question of the physical energy source for gravity

In gravitational acceleration masses gain energy. What is the physical energy source? Surprisingly, this seemingly down to earth question of physics is not well settled. Scientists, particularly from the field of cosmology have expressed that ‘gravity’ or ‘gravitational energies’ must have a negative character and the idea has inspired speculation about a zero-energy universe [5][6][7][8]. While this has been instrumental in inflation theory, no wider physical concept has evolved. Both the standard Lambda-CDM model for the energy content of the universe and current single-energy general relativity exclude negative energies. The leading legacy concepts for the source of energy in gravity are positive gravitational potential energy and positive energy from the gravitational field.

3.2 Gravitational potential energy

The math associated with the concept of gravitational potential energy predicts how much energy can be transferred between two massive bodies over a certain distance. Can gravitational potential energy also constitute the physical energy source in gravity? The concept of energy currently lacks clear distinction between a physical phenomenon present in space that can serve as a physical energy source and a mathematical operator that serves to predict the outcome of physical processes. The two may coincide as it is the case with physical forms of positive energy. In gravity this distinction between a physical phenomenon and a mathematical operator becomes crucial. Physical attributes of energy have

been identified thanks to the works of Albert Einstein. The presence of energy carries a specific mass-equivalent and is the source for gravitational effects. This fundamental behavior is used as a test for the presence of physical energy. Accordingly, physical energy requires:
- a determinable value with a determinable mass equivalent[8]
- a presence in space that is a source for gravitational effects

Gravitational potential energy has no mass equivalent and no value is even determinable. The concept of gravitational potential energy serves to calculate incremental amounts of energy that can be delivered by gravity between specific massive bodies over a certain distance. Yet, any attempt to determine a specific value for the gravitational potential energy of a mass floating in space is bound to keep escalating absurdly as there is no baseline[9]. From a perspective informed by the new theory the lack of a baseline and a determinable value makes perfect sense as we are looking at more and more positive energy being delivered at the expense of more and more negative energy in space.

Gravitational potential energy also fails to display the related characteristic of physical energy: A presence in space exerting gravitational effects. The concept of gravitational potential energy does not provide a clear suggestion for its location in the first place. Moreover, under general relativity no explicit gravitational effects are attributed to any presence of gravitational potential energy. The curvature of spacetime is due to the presence of mass and other forms of energy. This is determined by the energy-momentum tensor. The application of this tensor includes all forms of energy, with the explicit exception of gravitational energies. As gravitational potential energy lacks the characteristics of physical energy, it is not a physical energy source. Gravitational potential energy serves as a mathematical placeholder for what physically is an exchange with negative energy in space.

3.3 Energy from the gravitational field cannot be the energy source for gravity

The obvious expected location for gravitational energy would be the gravitational field. The question whether the gravitational field carries energy has long been a concern in physics, while an associated energetic particle, the graviton has remained elusive. The question here is whether such energy, if any, could possibly be the energy source for gravitational acceleration. There is a fundamental logical problem for that. Energy in order to serve as a physical source needs to be present prior to the delivery of the energy. This is not the case with the gravitational field. In the beginning of the accretion process of a massive body no substantial gravitational field even exists and it only grows in strength as masses keep falling in, gaining kinetic energy in the process. This is not the behavior of a system transferring positive energy. There is no form of energy in the field that could serve as the source for the energy delivered. The concept of energy from the field as the physical energy source is incompatible with fundamental logic.

3.4 Negative gravitational potential energy, negative energy in the field

An alternative assumption of a negative gravitational potential energy recognizes a negative character of energy in gravity but it does not provide a physical solution that locates physical negative energies. A

[8]The mass-energy equivalence principle which in its fundamental, non-relativistic form is expressed as $\mathrm{E} = \mathrm{mc}^2$, where E is the energy, m the mass and c the speed of light.
[9] Assuming a rock with a mass of 1Kg floating in space, when would its full potential energy be realized? It may be attracted into the nearest black hole, which may later merge with others in the universe. There is no baseline, any values would keep escalating absurdly until all masses in the universe were considered merged.

further alternative assumption of negative energy in the gravitational field is in conflict with the repulsion to be expected between physical entities of positive and negative energies.

3.5 Conclusion

There is no positive physical energy source for gravitational acceleration. No gravitational impact can be demonstrated, no location can be pinpointed and no value can be determined for a positive energy source. As the energy source can only be negative, the energy in gravity is gained at the expense of negative energy in space where changes follow $\Delta E_{neg} = -\Delta E_{pos}$. The values for negative energy from gravity are readily defined and its gravitational impact is detectable from repulsive gravitational effects on positive energy.

4 Description of the dual-energy mechanism in gravity

Under the new theory energy in gravitational acceleration is generated at the expense of an increase of negative energy in space. Conversely, in work against a gravitational field negative energy is reduced. Negative energy affects space in what is to be determined as either a local or nonlocal effect. The dual-energy mechanism reflects a symmetry of energy where the conserved quantity is the value zero. There is no physical potential gravitational energy, neither positive nor negative, associated with any configuration of masses in space. The example of elliptical orbits provides an illustration: In the legacy model energy in elliptical orbits observes

$$\mathrm{E} = \mathrm{E_k} + \mathrm{E_p}$$

where E is the system's total positive energy, $\mathrm{E_k}$ is the kinetic energy and $\mathrm{E_p}$ is the potential energy. In acceleration phases while moving towards the narrowest point in orbit, kinetic energy is gained at the expense of potential energy. In deceleration phases it is the other way around. What the legacy model describes as transfers of positive energy between potential energy and kinetic energy are recognized as physical interactions with negative energy in space under the new theory. In acceleration phases negative energy in space increases, in deceleration phases it decreases. The math for the change in negative energy is straightforward:

$$\Delta \mathrm{E_{neg}} = -\Delta \mathrm{E_{pos}}$$

where $\mathrm{E_{pos}}$ is positive kinetic energy and $\mathrm{E_{neg}}$ is negative energy in space.
The suggested underlying symmetry of energy is

$$\mathrm{E_{pos}} + \mathrm{E_{neg}} = 0.$$

This consideration of energy is relevant for a quantitative cosmological assessment of how negative energy in space evolves over time. For these purposes a fundamental distinction from general relativity is needed. It requires the consideration of a cosmological reference frame defined by the presence of masses in the universe and an isotropic CMB. The evolution of negative and corresponding positive energy is reflected in a 'fingerprint' of mass concentrations in space. As the quantitative assessment evaluates the energies involved in mass aggregation/collapse it is heavily influenced by the growth of mass concentrations in the most compactified astronomical objects. Accordingly, black hole growth and black hole mergers are expected to be significant contributors to increases in negative energy. A comprehensive cosmological assessment of the evolution of negative energy is dependent on the development of an understanding of the abundance of classes of black holes and of merger events in the universe. This is crucially linked to continued advances in gravitational wave astronomy following its ground breaking introduction by the LIGO and Virgo Collaborations[10], B.P. Abbott et. al. [9]. Eventually, correlations may be evaluated between the evolution of positive-negative energies as evidenced in mass concentrations and the evolution of the Hubble parameter. Information obtained through completely different channels relate to the same evolution of positive-negative energy. The suggested dual-energy mechanism has specific implications for the question of energy in gravitational waves. Under the dual-energy mechanism these merger events are associated with net increases of negative energy in space. This distinction from the current single-energy concept is addressed in 6.

5 Is it a local or a nonlocal effect?

Under the new theory negative energy is distributed thinly across space resulting in the observable expansion of the universe. The question is, how does negative energy get to affect space from local points of gravitational action? The fundamental alternatives are a nonlocal effect or a local effect. In the local scenario negative energy propagates out at the speed of light resulting in increases in negative energy. In work against a gravitational field, as in deceleration phases of orbits, the propagation of positive energy would be expected. It should be noted, however, that no evidence for the propagation of positive energy from work against a gravitational field appears to exist. In the nonlocal scenario we are looking at a novel nonlocal effect where space at large assumes an increasing, or, in work against a gravitational field a decreasing level of negative energy.

In the nonlocal scenario the distribution of negative energy across space is perfectly smooth. In the local scenario the distribution is still very smooth as net negative effects have been spreading throughout eons of increasing gravitational mass concentration. The question of a local or nonlocal effect may make only a negligible difference in developing and calibrating the new dynamic cosmological model at this stage. But the question is crucially linked to the determination of the unexplored fundamental properties of this new physical world of negative energy. It also relates to potential developments of negative energy based fundamental energy concepts in other areas of physics. At this point it is treated as an open question. Initial indications support the possibility of a nonlocal effect: i) Apparent absence of evidence for propagation of positive energy. In the local scenario positive energy propagates into space in work against the field, e.g. in deceleration phases of elliptical orbits. While negative energy is easily overlooked, familiar positive energy should be detectable. At this point no evidence seems to support this scenario. ii) Quantum physical phenomena and affinity of their math: Quantum physics has long demonstrated that our world is not all local. Its mathematical framework requires complex numbers that include the imaginary unit, the square root of -1. This is consistent with expectations for a fundamentally negative physical world where familiar concepts from positive energy do not apply. iii) Negative energy has not been physically tested. It may be a fundamentally nonlocal phenomenon where the speed limit of light does not apply.

6 Consequences for energy in gravitational waves

Current single-energy models assume that gravitational waves carry positive energy [9]. This assumption had gained recognition after precise observations of a pulsar in orbit with a radio-silent companion, PSR

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[10] See Ligo.org for comprehensive and updated information on the first three observing runs.

1913+16, also referred to as the Hulse-Taylor binary[11]. Weisberg, Taylor, Fowler demonstrated [13] that It could be concluded from the gradual acceleration of orbital periods, that the orbits were shrinking and that the narrowest position of the orbit, the periastron, was moving in line with predictions from general relativity. Subsequent observational results and advanced modeling have further confirmed that the shrinking orbits were due to relativistic effects [14]. Crucially, however, the interpretation of the energy flow has been based on the single-energy model where gravitational potential energy is a form of positive energy and therefore the shrinking orbits are seen as evidence that orbital energy must have been lost [13]. With no plausible alternative destination for the assumed loss of energy the conclusion that it was carried away by gravitational waves seemed reasonable. With the realization that potential gravitational energy is not a physical form of energy, the basis for this conclusion falls away. Under the dual-energy mechanism there is no loss of energy due to shrinking orbits which needs to be accounted for. In lower orbits kinetic energy is increased at the expense of an increase of negative energy in space. Merger events are associated with net increases of negative energy in space. The new theory calls for a reconsideration of modeling of energy in gravitational wave events. A new question that carries cosmological relevance is how much negative energy of space is generated in these events.

7 Impact of dual-energy principle beyond cosmology

7.1 One fundamental nature of energy, not two

The dual-energy mechanism in gravity demonstrates a positive-negative symmetry of energy. In the model of the not quite so big bang it is assumed that the dual-energy principle applies universally to all forms of energy including matter. What suggests a truly universal symmetry of energy with a conserved universal value of zero, as opposed to a phenomenon limited to modern gravity? Any conserved universal value other than zero would imply an inconsistent fundamental nature of energy. Some of the energy in the universe would originate from a positive-negative symmetry of energy, some resulted from an initial value of positive energy arising asymmetrically in the physically incoherent concept of a big bang singularity. This suggests a universal positive-negative nature of energy beyond gravity and a conserved universal value of zero.

7.2 Cosmological evidence suggests reevaluation of fundamental energy concepts in quantum physics/particle physics

The new theory demonstrates that a fundamental positive-negative structure of energy is essential to address the origin and expansion of our world of energy. The findings based on cosmological evidence suggest that positive energy has emerged from the beginning in a not quite so big bang along with corresponding negative energy. The findings also demonstrate the fundamental role of gravity for the genesis of energy. Yet specific processes for the emergence of energy from the beginning in a not quite so big bang are unknown. The fundamental positive-negative symmetry of energy suggests a path to redefine or complement fundamental energy concepts in quantum physics/particle physics to where positive energies ultimately are matched by corresponding negative energy.

In quantum field theory the need for a dual-energy approach already is evident from the unrealistically inflated expected values for the vacuum energy of space from zero-point quantum fluctuations as described in 2.5. The dual-energy principle also adds a fundamental concern to more recent doubts

[11] After Russel Hulse and Joseph Taylor for their discovery of the binary.

about the ability of the Higgs mechanism to explain the masses of the heaviest elementary particles [15] based on a field of distinct positive energy permeating all of space.

8 Relationship between dual-energy theory and general relativity

Dual-energy theory provides answers to questions of origin and expansion where general relativity in its current form breaks down. The newly identified positive-negative symmetry of energy presents itself as a fundamental building principle of our universe. Under general relativity the principle of conservation of energy is not reflected[12]. No symmetry of energy is expressed and negative energy is currently not considered. The representation of energy in current general relativity is incomplete. The insufficiency goes beyond the mere consideration of the presence of negative energy in space. It extends to the purely relativistic treatment of energy[13]. The assessment of the evolution of energy in the universe requires a cosmological reference frame defined by the presence of masses in the universe and an isotropic CMB. This reference frame is shown to be relevant to explain and model the fundamental evolution of energies in the universe.

9 Conclusion

A transformational new understanding of energy and gravity is presented. The extraordinary suggestion of a new theory of gravity and energy is supported by extraordinary evidence. It is shown to deliver the comprehensive, coherent and detailed qualitative outline of a new cosmological model from one principle. It naturally provides a physical model for numerous of the hardest questions in current theory including the mysterious dark energy, the problem of an initial singularity, the flatness of the universe and the fundamental question of origin of energy. It demonstrates the current Lambda-CDM model is fundamentally flawed. An adaptation of the proposed DEC model suggests sweeping changes in cosmology. Throughout the field fundamental interpretations need to be reconsidered, quantitative and qualitative models adapted, entirely new models developed and applied. New sets of data need to be established and calibrated. The starting point of dual-energy cosmology provides pioneering opportunities for further imminent insights. Beyond new solutions in cosmology, dual-energy theory demonstrates a clear-cut fundamental alternative to the current physical world view of a world of positive energy only. The highly consequential suggestion invites a robust and broad discussion. An unchartered physical world of negative energy needs to be explored. Further transformational developments in fundamental physics may be expected.

[12] A concern which led to the earlier proposal for the addition of the 'Landau-Lifshitz pseudotensor' after Lev Davidovich Landa and Evgeny Mikhailovich Lifshitz.

[13] The inadequacy for fully representing energy without a cosmological reference frame can also be illustrated with a relativistic energy 'paradox': To an observer on a spaceship accelerated to near the speed of light galaxies in front and rear seem to be supercharged with kinetic energy as they approach or recede at near the speed of light. They are not, the assessment of energy evolving in the universe requires a cosmological reference frame.

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