Negative Energy from Gravity (NEG)
Concept, proof and sweeping implications for cosmology and theoretical physics
Introduction of new Dual Energy Cosmological model (DEC) and new dual energy physics
NEG reveals physical structures employed in theory of AdS/CFT correspondence

By Ralph B. Hill, September 2019

1. Introduction

This paper addresses the fundamental question of where does the energy come from, that gravity delivers as well as the evolving sweeping consequences for physics and cosmology.

Traditionally the source of energy delivered by gravity has been attributed to a positive gravitational energy potential. However, physicists have suggested that 'gravity' or gravitational fields must be negative. Most notably in the context of inflation theory[1] and in the context of explaining the existence of energy in the universe[2].

While (positive) energy is generally defined as the capacity for doing work, I will show that in gravitational acceleration work arises from zero while positive energy is harvested at the expense of a buildup of negative energy in the same amounts, as illustrated by the term 0=-1+1[3]. The negative energy corresponding to the positive energy delivered builds up as negative energy in space and its effects are observable. I will refer to the negative energy from the workings of gravity as NEG[4].

The increasing amounts of NEG in the universe through its evolution driven by gravity is quantifiable by astrophysical analyses and estimates. The antigravitational forces that areas of space dominated by negative energy are expected to exert on (positive) mass-energy[5] have direct implications on how the universe behaves at large scales. NEG is involved in the expansion of the universe and the observed acceleration of its expansion rate.

From the very clear cut and basic concept of NEG a whole new picture emerges about the nature of gravity, energy and space. It has sweeping implications for cosmology and other areas of physics.

I suggest that the theory of NEG comes with clear and compelling evidence from the outset, as it follows directly from the stringent application of established and proven physical principles of what energy is and does. It is supported by hallmarks of what should be expected from of a theory that reveals a missing piece of nature and delivers new fundamental insights into the nature of gravity, energy, space and time. It sweepingly addresses a range of previously considered independent discrepancies between observations and current modeling in cosmology. It resolves a wider energy problem in theoretical physics due to an incomplete understanding of the phenomenon of energy.

[1] In versions of inflation theory, negative energy from the gravitational field compensates for the exponential increase in energy, during inflation from an initial positive energy potential of a false vacuum, Alan Guth, WAS COSMIC INFLATION THE 'BANG" OF THE BIG BANG? 'The Beamline' 27, 14 (1997), 3. THE INFLATIONARY UNIVERSE. Retrieved from https://ned.ipac.caltech.edu/level5/Guth/Guth_contents.html
[2] One example is Stephen Hawking, The Theory of Everything, 2007, Jaico, Mumbai (book first published in 2002).
[3] Rather than the lean 0=1-1 expression I use 0=-1+1 to highlight the principle.
[4] Depending on context NEG may denote either the negative energy from gravity or the theory.
[5] This follows by extension from Newton's law of universal gravitation when one of the mass-energy objects is negative.

2. Highlighting the evidence

The core of the evidence detailed over the next sections is based on the realization that nature offers tests for the presence of energy. These tests can be found in well proven physical principles. They just have not been applied to gravity. These are[6]

- Energy has a specific mass equivalent (the mass-energy equivalence, $e=mc^2$)
- Energy curves spacetime (as represented by the 'energy-momentum tensor'[7] in general relativity)

Both the gravitational 'field' and the textbook concept of 'gravitational potential energy' of massive bodies fail these tests. Neither carries energy. As the energies delivered by gravity must be taken from somewhere, the consequential answer is the buildup of negative energy elsewhere.

As this follows straight forward from what we already know about energy one may wonder why this has not been addressed yet. Somehow gravity has escaped this scrutiny with an understanding that it is just different, and the answer to the question of the energetic source does stretch current physical understanding and unleashes far reaching consequences.

3. No positive energy source

The concept of a positive energy source for gravitational acceleration appears questionable from a big bang perspective. The textbook concept of gravitational potential energy implies that a homogenous distribution of mass-energy in space represents a maximally charged state of energy. This would constitute a questionable upper limit for this form of energy. Shouldn't a homogenous distribution rather reflect the primordial birthplace of mass-energy representing an energy level of zero[8]?

This calls for verification of the concept of gravitational potential energy. According to the mass-energy equivalence principle, expressed in its basic form as $e=mc^2$ and $m=e/c^2$, energy has proper localizable amounts of energy which have specific mass-equivalents. Since the discovery and first realization of the principle, this has been shown to extend to all forms of energy, with the notable exception of gravitational potential energy. The concept of gravitational potential energy has been used successfully only to quantify energy potentials in relation to earth's and other massive bodies' gravitational fields but not for determining absolute values for gravitational energy which could be assigned a mass equivalent.

Where would a bottom line be reached at which all gravitational potential of a mass would be realized? In a scenario where a mass is falling into a black hole, it still has more gravitational potential, which may be realized in consecutive mergers with any number of other black holes in the universe, until all masses in the observable universe, and beyond, have been considered. Values for $m=e/c^2$ escalate unrealistically in this model. Any attempt to assess an absolute value for the gravitational potential energy of a mass under for $e=mc^2$ and $m=e/c^2$ is doomed. Since there can ever more energy be delivered by gravity, no mass-equivalent can be attributed. In this scenario of ever more energy being delivered

[6] A third one would be the existence of an associated energetic particle.
[7] Alternatively referred to as 'stress-energy tensor'.
[8] Considerations described below 9. And 15., suggest that it *represents* the smooth background prior to traces left from gravity delivering energies. The relative positioning of masses always *carries* zero energy at a homogenous or at any other distribution level.

through the workings of gravity we are looking down an open-ended scale. This leads to the realization that until now we did not know where the energy in gravitational action comes from.

There is no other positive energy source either[9]. The gravitational potential fails the mass-equivalence test. It is not energy.

4. Energy from what?

The energy that gravity delivers does not arise from zero at no cost. This follows by extension from the principle of conservation of energy. Without a positive energy source, the energy must be taken at the expense of a buildup of negative energy in the same amounts.

5. Where is the negative energy?

This leads us to the conclusion that there must be a whole world somewhere, of negative energy, that curves space negatively, that exerts an antigravitational force[10] and has a negative mass equivalent. And we have not detected it yet, or have we?

a) Could the negative energy be in the gravitational field?

It has been suggested that the gravitational field carries negative energy[11]. However, there is a problem with this suggestion. General relativity has shown with great success how the local presence of mass and energy influence the geometry of spacetime:

The presence of mass and all forms of energy cause spacetime to curve, however, the energy-momentum tensor[12] which is the source of spacetime curvature in the field equations in general relativity, reflects a value of zero for any local 'gravitational energy'. On this basis of zero energy from the gravitational field, general relativity through its precise verifications by observation, have successfully demonstrated that the gravitational field itself carries no energy, neither positive nor negative. The 'gravitational field' exclusively is the effect of curvature of spacetime without any contribution to curvature.

If it does not behave like energy, it's not energy.

No need has arisen from observations of effects of stationary gravitational fields to correct this standard approach of zero energy in the field. However, in the context of the propagation of fields, i.e. in gravitational waves, a transport of energy has been proposed. These questions are examined in a separate section on gravitational waves[13]. The observation and interpretation of gravitational waves holds an important key for understanding the exact way in which negative energy becomes a property of space[14].

[9] No positive energy can be contained in the 'field' as the gravitational field builds up after gravitational action.
[10] This already follows from Newton's law of universal gravitation where the negative sign on one of the masses considered reverses the direction of the force.
[11] One of several is Stephen Hawking, The Theory of Everything, 2007, Jaico, Mumbai. Yet no wider concept has emerged.
[12] Alternatively referred to as 'stress-energy tensor'.
[13] See 8.
[14] See the question of a local or nonlocal scenario 6. And 8.

b) Could the gravitational potential just be negative and carry the negative energy?

The consideration for a gravitational potential energy to be negative represents a step in the right direction as it redefines level zero for energy and avoids escalating mass equivalents[15]. However, for it to be physical energy would require a localizable and detectable impact on curvature. And just as described above for the gravitational field, no such effect can be shown. There is no localizable negative energy here.

c) Remote location

As we are left with no detectable amounts of negative energy at the scene of massive astronomical objects, we need to look for it elsewhere. Over the gravitationally dynamic history of the universe galaxies have been using up more and more star forming material and black holes have continued growing. As mass accretion has progressed, NEG must have been increasing.

I suggest NEG is a contributing factor in the expansion of space and in the observed acceleration of its expansion rate. I suggest that there is no positive 'dark energy' and that the acceleration of the expansion ascribed to 'dark energy', reflect effects from NEG at levels still to be determined.

6. How does the negative energy get into 'space'?

This could be by way of one of two principally different alternatives:

a) The local scenario: While a mass is accelerated by gravity, negative energy propagates out at the speed of light.
b) The nonlocal scenario: A conceptually novel nonlocal effect where space at large assumes an increasing charge of negative energy.

The question of which is the actual path in nature should eventually be testable through observations of gravitational waves as described further below. If localizable negative energies propagate out from these events, they should leave a detectable signature confirming the local scenario a). If no localizable negative energies propagate out, then negative energy is a nonlocal effect as described in the nonlocal scenario b).

7. Reduction of NEG in space from work against gravity

Positive energy spent on work against gravity[16] should lead to a reduction of negative energy following the principle of energy expressed in 0=-1+1. In a nonlocal scenario this implies a direct reduction of the level of negative energy of space. This is more differentiated in a local scenario, where any prior negative energy has already radiated away at the speed of light during acceleration of masses. As prior negative energy waves cannot just be undone, work against gravity instead leads to an independent positive energy wave contributing to a net reduction of negative energy over space and time.

8. NEG and gravitational waves

a) General

[15] But still needed detectable negative mass-equivalents, which also have not been shown.
[16] As in deceleration phases in orbital movements or a rocket launch from earth.

As first reported in 2016 the LIGO and Virgo collaborations have begun to successfully measure distortions of spacetime from gravitational waves and it was suggested that the gravitational waves carry significant amounts of energy away from highly energetic gravitational processes[17]. The interpretation of these waves has been based on the understanding of energy prior to the introduction of NEG and DEC.

b) Predictions from NEG and clarification of NEG orbital energy model

NEG offers clear predictions for gravitational waves, that serve as a test for the local scenario:
Acceleration phases during inspiral must carry away negative energy. Deceleration phases are expected to carry away positive energy. The net aggregated effect must be negative.
In the nonlocal scenario no energy is carried away in gravitational waves.

The model of orbital energy under NEG is markedly different from the traditional model. Under the traditional model the give and take relationship of energy in orbits is between positive gravitational potential and kinetic energy. Under NEG it is between kinetic energy and negative energy. Specifically, under NEG there is no positive energy potential in higher[18] orbits. Instead, lower orbits indicate the amounts of net positive energy delivered by gravitational acceleration at the expense of a buildup of net negative energy in the same amounts. The positive energy delivered is represented in higher kinetic energy.

c) The need to evaluate gravitational waves for negative energy

The assumption of gravitational waves all radiating away positive energy, appears out of line with the observation of an accelerating cosmic expansion from a dual energy viewpoint. If gravitational waves all carried positive energy away, orbital movements would continuously spew out positive energy both during phases of acceleration and deceleration[19]. In addition to the one-time positive energy from acceleration events in mass accretion and other non-periodical events this would fill space with an increasing charge of positive energy over the history of the universe for which there seems to be no observational equivalent. By contrast, under NEG negative energy from gravity has been aggregating, causing antigravitational effects[20]. The obvious suggestion from the energy-based approach of NEG is that gravitational wave signals need to be evaluated for signatures of negative energy.

d) No net positive energy in gravitational waves from loss of 'orbital energy'

A milestone in considering gravitational waves had been reached following the discovery and precise observations of a pulsar in orbit with a radio-silent companion, PSR 1913+16[21]. It could be shown that the narrowest position of the orbit, the periastron, was gradually moving closely in line with predictions from general relativity[22]. The predictions from general relativity were based on local relativistic time

[17] B.P. Abbott et. al., (2016) Physical Review Letters 116, 061102, 2016.
[18] Nor in any other orbits.
[19] The concept appears systematically flawed and seems to have been applied mainly in the context of explaining the flow of energy in shrinking orbits from an assumed reduction of 'orbital energy' which again rests on the flawed assumption of a positive gravitational energy potential.
[20] This aggregation should manifest itself in the overall antigravitational effects from negative curvature of space.
[21] Also referred to as Hulse-Taylor binary after Russel Hulse and Joseph Taylor for their discovery of the binary.
[22] Weisberg, Joel, Taylor, Joseph, Fowler, Lee, (1981), 'Gravitational Waves from an Orbiting Pulsar' Scientific American, October 1981, p. 81

dilation across different phases of the orbit[23]. It could be concluded from the gradual acceleration of orbital periods, that the orbits were shrinking[24].

The interpretation of the energy involved was based on an understanding that the shrinking orbits were the energy source for gravitational radiation[25]. This was seen as strong evidence for gravitational waves carrying away corresponding amounts of positive energy[26]. Subsequent observational results and advanced modeling have confirmed agreement between predictions based on the application of general relativity and observation of orbital decay[27]. However, the expected energy transfer was derived from the traditional model of orbital energy which is based on the concept of positive gravitational potential energy. This concept is incompatible with the mass-energy equivalence principle as shown earlier. There is no such positive energy potential and consequently the basis for the assumption of a net positive energy transfer from positive orbital energy to gravitational waves falls away. The shrinking orbits are associated with a net increase of negative energy.

e) Consequences for nonlocality

Following the realization that there is no net positive energy transfer from shrinking orbits it may be tempting[28] to just assume that the gravitational waves carry net negative energy and that the local NEG scenario is correct. However, conceptually, a nonlocal scenario is not at all excluded by the aforementioned considerations. If found to be applicable the nonlocal scenario may provide a path to understanding other nonlocal effects as observed in quantum physics. At this point the question of energy in gravitational waves and the connected question of nonlocality is not settled.

f) Direct determination of energy?

An earlier attempt to assess the question of the energy content of gravitational waves has included the 'sticky beads' argument which is fraught with uncertainties[29]. With LIGO[30] and Virgo[31] gravitational wave detectors up and running and set for continued improvement that type of approach seems outdated. Rather than hypothetical sticky beads we may consider actual laser beams in the lab. Can the question of the energy content in gravitational waves be determined from energy changes in laser beams following interaction with the wave? What can be learned from the differentiation of signals from acceleration and deceleration phases?

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[23] Weisberg, Joel, Taylor, Joseph, Fowler, Lee, (1981), 'Gravitational Waves from an Orbiting Pulsar' Scientific American, October 1981, p. 79.

[24] Weisberg, Joel, Taylor, Joseph, Fowler, Lee, (1981), 'Gravitational Waves from an Orbiting Pulsar' Scientific American, October 1981, p. 82.

[25] Weisberg, Joel, Taylor, Joseph, Fowler, Lee, (1981), 'Gravitational Waves from an Orbiting Pulsar' Scientific American, October 1981, pp. 76, 82.

[26] Weisberg, Joel, Taylor, Joseph, Fowler, Lee, (1981), 'Gravitational Waves from an Orbiting Pulsar' Scientific American, October 1981, p. 82.

[27] Joel Weisberg, Y. Huan, (2016), 'RELATIVISTIC MEASUREMENTS FROM TIMING THE BINARY PULSAR PSR B1913+16' The Astrophysical Journal, Volume 829, Number 1, 5.1

[28] In analogy to the prior model.

[29] Described by Bondi, Hermann (1957), 'Plane Gravitational Waves in General Relativity', Nature 179, 1072-1073. By design this thought experiment seems incapable of detecting negative energy and seems to rely on an assumption that not all of the space affected by the wave is distorted unisono, thereby creating friction.

[30] See Ligo.org.

[31] See Virgo-gw.eu.

g) An intriguing 'bonus question' of direct spatial expansion

As gravitational waves are expected to stretch and compress space along different axes at the same time the question is how this affects the overall volume of space affected by the wave. An expanding effect on space carried in gravitational waves from acceleration phases would point to a direct manifestation of negative energy in the form of expansion space. In this case net expanding effects could aggregate over time across space and provide an astonishing direct explanation for cosmic expansion. The question is, can an expanding or contracting effect on space in gravitational waves from acceleration or deceleration phases be determined?

Further modeling and observations should eventually clarify these questions.

9. How to quantify NEG in the universe – Novel astronomical survey to assess aggregate energies delivered by gravity

According to NEG the positive energy delivered by gravity corresponds with the buildup of NEG[32]. The levels of net NEG in the universe throughout its dynamic gravitationally driven evolution are of cosmological significance due to NEG's projected antigravitational effects.

The goal of this survey is to quantify the positive net energy delivered by gravity as this gives away the amounts of negative energy generated in the process. The prior net delivery of positive energy by gravity leaves a 'fingerprint'[33] on space in the form of accretion of massive bodies and any other mass concentrations within and between nearby galaxies, which render the historic aggregate calculable. This opens the door for a novel type of astronomical survey, which is set to deliver unprecedented data. It requires reasonable estimates on the basis of comprehensive astronomical inventory assessments for large representative subsections of space, each representing an epoch in the evolution of the universe. Here are some initial observations regarding this exercise:

a) Net positive energy delivered in the accretion of massive bodies are reflected in the accretion status of massive bodies[34]. Downstream effects from energy delivered initially through acceleration down a gravitational field such as heat, pressure and rotational energy are irrelevant.
b) The energy delivered in the accretion of the most compactified objects disproportionally[35] dominates levels of NEG. A comprehensive understanding of classes of these objects and their abundance is of particular relevance. The evolving field of gravitational wave astronomy[36] is essential for achieving this goal.
c) An important methodical issue concerns the assessment of energy delivered in the case of black holes. Physicists have struggled with removing singularities arising in the modeling of black holes. Such singularities imply infinite amounts of energy, which is either a problem of the

[32] And positive energy.
[33] What these 'fingerprints' may constitute is discussed in 15.
[34] Mass, compactification, i.e. location of masses within body. The calculatory exercise involves the energy required for acceleration of all particles of massive bodies out of the influence of gravitational fields.
[35] Compared to overall masses involved.
[36] Note the early promising results from the LIGO and Virgo Collaborations: The LIGO Scientific Collaboration and the Virgo Collaboration (30 November 2018), 'GWTC-1: A Gravitational-Wave Transient Catalog of Compact Binary Mergers Observed by LIGO and Virgo during the First and Second Observing Runs'.

model or would be one in the physical world. In a separate paper I will make a suggestion how the singularities disappear and in which the energy involved is calculable.

d) The question may be raised whether we need to look at kinetics at all in order to infer the energy delivered by gravity. From the way NEG works the aggregated net energy at any moment in time is given by the relative positioning of masses. It is irrelevant whether the resulting positive energy is manifested in kinetic energy, heat, pressure or any other form of positive energy. For practical purposes, when considering orbits, the average proximity to the central mass renders the required point of reference for assessing energy.

e) A fundamental issue arises of how to consider the effect of apparent acceleration of galaxies due to the expansion of space, which also leads to stronger accentuation of mass concentrations on the big picture of distribution of mass-energy in space[37]. From the energy centered perspective of NEG, the guiding question is whether or not energy is being delivered in the apparent acceleration of galaxies due to the expansion of space. This points to two alternatives: i) These are only apparent motions due to the expansion of space which do not represent kinetic energy and the effect may be ignored. ii) They represent positive kinetic energy produced along with negative energy by the work of antigravitational forces between areas of space dominated by negative energy and adjacent groups of galaxies. This then constitutes an additional element driving accelerated expansion. The determination between the two alternatives may be eventually addressed by calibration of the new dynamical DEC model[38]. For now, this may be considered an open question.

With the addition of the novel NEG survey to the existing methods to determine the Hubble 'constant' we will be examining two related but different phenomena pertaining to different locations. The existing Hubble constant measurements relate to effects from the expansion of space between groups of galaxies, while the novel NEG survey relies on fingerprints left behind from the delivery of energy by gravity within galaxies. Thanks to the clear-cut mechanism in NEG we can relate measured values from the two effects and verify the role which NEG plays in cosmic expansion. We are set to gain a new analytical tool with the potential to improve accuracy and detail of cosmological models. What these 'fingerprints' may constitute is discussed further below[39].

10. Impact of NEG on general relativity:

General relativity in its current expressions without NEG cannot coherently explain where the energy arising locally in gravitational action is taken from. Also, general relativity has been struggling to find meaningful expressions of the principle of conservation of energy in curved spacetime. Last but not least general relativity without NEG has not been able to explain the large-scale dynamics of the universe. This calls for an expression of NEG in general relativity.

11. Examples of conceptual insights from NEG

Perceived oddities of gravity and a number of other prominent fundamental questions in physics are readily addressed. To highlight just a few:

[37] In this paper also referred to as the 'fingerprint'.
[38] See the outline of the emerging DEC model below 14.
[39] See 15.

a) Why is gravity much weaker than other energetic fields? Gravity is not an energetic field, there is no energy spread across it or dissipating into extra dimensions. Gravity makes energies from zero. The gravitational field and the force of gravity are currently best described as a characteristic of spacetime geometry.
b) Why has the graviton remained elusive? There is no graviton with positive energy as there is no energy in the gravitational field.
c) As described in the next chapter below, NEG explains the one directional flow of time.
d) How energy can emerge as opposed to be considered a given quantity.
e) Calculations made for vacuum energy from zero-point quantum fluctuations have been suggesting a vacuum energy of some 120 orders of magnitude too large for effects observed. NEG offers proof of principle that negative energy can build up in space along a release of positive energy, supporting that these fluctuations come and go with corresponding amounts of negative energy[40].

12. What is gravity and what is the role of time?

A stunning new picture of what gravity is, emerges from what gravity does. The work of traditional forces transfer energy. Gravity is fundamentally different. Gravity does not transfer any energy. Gravity creates energy from zero in a 0=-1+1 type fashion. It directs positive and negative energies across space. The fingerprint of locations of mass-energy in space gives away the aggregated amounts of positive and negative energy delivered. Gravity presents itself as a process of bifurcation of energy in space.

With energies arising from gravity's effect on space in a most basic 0=-1+1 type fashion, time has not appeared essential to address this fundamental concept. The question is, what is the role of time? NEG provides suggestions to answer this question:

Firstly, there is antigravity only in the sense of antigravitational effects between negative energy and positive mass-energy. But there is no 'antigravity' in the sense of a reverse bifurcation flow leading to a recombination of negative and positive energy, which actually repel each other. This explains why the arrow of time can only point in one direction. Secondly, when we look at gravity as a dynamic bifurcation process, we observe varying speeds of progression dependent on local concentrations of mass-energy. At their strongest, at the event horizon of black holes, the flow comes to a standstill reaching a cul-de-sac. This links time to the flow in the bifurcation process. It demonstrates how time can come to a standstill. Time present itself as a dynamic, one directional and locally varying flow in the bifurcation process[41].

The fundamental insights can be summarized: Gravity creates energy through bifurcation, fills space with negative energy, directs the flow of energy in space and defines time as the local speeds in the flow of energy.

13. The scope of the energy problem in physics

[40] Negative energy in quantum field theory was initially proposed by Paul Dirac (1930), 'A Theory of Electrons and Protons', Proceedings of the Royal Society London A 126 (801), 360-365, doi:10.1098/rspa.1930.0013. In the context of suppression of vacuum fluctuations see Larry Ford, (2009), 'Negative Energy Densities in Quantum Field Theory', arXiv:0911.3597.

[41] This may open the door for bifurcation models of gravity to be formulated and related with general relativity.

Physics has an energy problem. The problem manifests itself at different levels. At short range, at long range, across the spectrum, on a fundamental level and in the very beginning. It all is linked to the omission of negative energy.

The struggle to find alternative explanations has led to patches at different levels to make concepts without negative energy appear coherent or to bring numbers in line with observations. These patches designed to address a deficit on one level do not provide explanation for deficits on other levels. This is a summary of these issues[42]:

- At short range lies the struggle to identify a local source for energy in gravity,
- at long range the struggle to coherently address the antigravitational forces behind large scale movements in the universe,
- across the spectrum is the struggle to express the principle of conservation of energy in general relativity,
- on a fundamental level the struggle, or the lack thereof, to demonstrate processes giving rise to positive energy,
- in the beginning lies the struggle to identify a very initial source for energy and to deal with an initial singularity.

These patches include:

- At short range the concept of gravitational potential energy. It provides nothing to explain the antigravitational forces behind large scale movements in the universe, nothing to give relevance to the principle of conservation of energy in general relativity, nothing on the fundamental question of energy and offer nothing on the question of a very initial source for energy.
- At long range patches include the proposal of some negative pressure as a driver for expansion and an unexplained positive form of energy with antigravitational effects, currently termed dark energy. These patches provide nothing on the local source for gravity, nothing to give relevance to the principle of conservation of energy, nothing on the fundamental question of energy and offer nothing on the question of a very initial source for energy.
- The lacking of general relativity to reflect the principle of conservation of energy has been addressed with the introduction of the Landau-Lifshitz pseudotensor[43] which recognizes the deficit but does not address any of the other issues.
- The fundamental question of what gives rise to positive energy and if there is negative energy has been addressed by inflation theory within its scope, yet this has not evolved into a wider concept addressing other issues.
- In the beginning lies the patch of positive energy only false vacuum, which does not address any of the other issues.

Despite these alternative explanations the numbers still do not match observations at the long range[44]. The quantum physical problem of an absurdly exaggerated value for the vacuum energy of space

[42] This is to summarize. Individual issues are addressed in more detail under DEC and other parts of this paper.
[43] Lev Davidovich Landau, Evgeny Mikhailovich Lifshitz, (1951), The Classical Theory of Fields, chapter 11, #96, Pergamon Press
[44] 'New Hubble Constant Measurement Adds to Mystery of Universe's Expansion Rate', article July 16, 2019, regarding measurements of the Hubble constant by Wendy Freedman et al, retrieved on

persists without an acceptance of negative energy[45]. The wider understanding of the phenomenon of energy with positive and negative energy in a 0=-1+1 type relationship addresses all these issues. And the new concepts of NEG and DEC provide a deeper and coherent understanding of the nature of gravity, space and time.

14. The emerging Dual Energy Cosmological model (DEC)

a) The new dynamic model

With NEG cosmology is set for a revolutionary leap forward. The previously unresolved question, of what is the nature of 'dark energy' is directly addressed. Moreover, what has presented itself as a confounding question in itself, is just one of the puzzle pieces that falls into place. With proof of principle for negative energy as a consequence of NEG, the obvious suggestion is that what looks and works like an antigravitational effect in the universe is an antigravitational effect due to a form of negative energy. There is no more need to explain these effects with other types of pressure.

This affects the antigravitational behavior of space which has been attributed to a cosmological constant 'lambda'[46] and it renders the current standard Lambda-CDM model obsolete. The energy content of the universe consists of both positive and negative energy. The assumed dark matter in the outskirts of galaxies is partially or rather completely an artifact of models omitting the antigravitational effects of negative energy from the surroundings of galaxies and groups of galaxies.

With the inclusion of negative energy, a whole new picture emerges where the large-scale movement of masses in the universe is driven by the pushing and pulling of gravitational and antigravitational forces. Spacetime is found to consist of positively curved areas as well as areas with negative curvature. The current model is to be replaced by a new dual energy model which includes negative energy.

b) A not quite so big Big Bang without a singularity

NEG makes clear suggestions for the earliest stages of the Big Bang. Energy is shown to evolve in a process of bifurcation. The assumption of a false vacuum representing initial positive energy, as modeled in inflation theory[47] is unnecessary. NEG suggests that a space like quantity evolved in a process of bifurcation releasing positive and negative energy.

This also means that there is no more need to assume an initial singularity and to assume that all energy be present in the very first definable instant of this process. Instead, the new theory of energy introduced by NEG, opens the door for models where mass-energy and elementary particles evolve step by step early on in the evolution of the universe.

c) New Questions

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https://www.nasa.gov/feature/goddard/2019/new-hubble-constant-measurement-adds-to-mystery-of-universe-s-expansion-rate

[45] Though proposals have been made, see Larry Ford, (2009), 'Negative Energy Densities in Quantum Field Theory', arXiv:0911.3597.

[46] Which points to a negative energy charge from the emergence of mass-energy early in the evolution of the universe.

[47] Alan Guth, WAS COSMIC INFLATION THE 'BANG" OF THE BIG BANG? 'The Beamline' 27, 14 (1997), 3. THE INFLATIONARY UNIVERSE. Retrieved from https://ned.ipac.caltech.edu/level5/Guth/Guth_contents.html

New questions arise such as: How does the energy content of the universe add up? Do we live in a zero-energy universe with matter and other positive mass-energy all having a negative energy equivalent? Does the universe appear flat just because positively and negatively curved areas cancel each other out on large scales? How can the emergence of positive mass-energy in the early phase of the big bang be modeled with an early release of negative energy? Was there an inflationary period? How does such early release of negative energy fit in with the evolvement of the Hubble 'constant'?

d) Astronomy gets a new way to look at the universe[48]

Astronomy is set to develop an interest in the history of gravitational action. With NEG and DEC, we want to quantify the historic positive and negative energy delivered by gravity through epochs of the universe and compare with antigravitational effects from negative energy. The question of historic generation of energy goes beyond variations of the Hubble constant observed. It includes the question of what gave rise to lambda in the early cosmos. As ultra-compactified objects are particularly relevant, a representative census of these objects is becoming of heightened relevance, including the question of existence of primordial black holes. The fundamental question of what these 'fingerprints' of mass concentrations in space represent is addressed separately in the following section.

This marks just the starting point of a new cosmological model. The development of DEC requires an ongoing scientific effort to evaluate and quantify the actual dynamics at play. Existing observations need to be reevaluated and a novel type of astronomical survey is suggested. The parameters of the new model need to be identified and calibrated with increasing precision along with future observations.

15. NEG reveals structures employed in theory of AdS/CFT correspondence as partial components of physical reality

The conjectured so-called AdS/CFT correspondence has become a very active and well publicized area of theoretical research despite a seeming lack of its very basis in our physical world, a negatively curved 'Anti-de Sitter' space. It examines rather surprising dualities between string theoretical models containing gravity with conformal quantum field theories on a lesser dimensional holographic[49] boundary. This evolved following an initial proposal in 1997 by physicist Juan Maldacena[50].

a) Negatively curved 'Anti-de Sitter' space

NEG and DEC reveal negatively curved space to actually be one component or aspect of space in the universe. While we do not live in a universe with only negative curvature, the revelation is set to open the door and provide guidance for applying principles and mathematical models examined in the theory of AdS/CFT correspondence to real world formulations within a dual energy description of the universe.

b) Does the 'fingerprint' of mass concentrations represent a holographic boundary?

[48] This refers to the novel astronomical survey described in 9.

[49] The holographic principle had been suggested outside the AdS/CFT context, Gerard 't Hooft (1993), 'Dimensional Reduction in Quantum Gravity', arXiv:gr-qc/9310026, Leonard Susskind (1995), 'The world as a hologram', Journal of Mathematical Physics, 36, 6377-6396, doi:10.1063/1.531249.

[50] Proposed by Juan Maldacena in 1997, 'The Large N limit of superconformal field theories and supergravity', International Journal of Theoretical Physics, April 1999, Volume 38, Issue4, pp 1113-1133, DOI:10.1023/A:1026654312961.

This refers to the novel astronomical survey suggested earlier[51]. A rather stunning insight has been derived from a first analysis of how to calculate the amounts of positive and negative energies released during the gravitationally driven evolution of the universe. Under NEG the relative positioning of positive mass-energy in space does not carry energy. Yet the status of concentration of mass-energy in the universe, the 'fingerprint' left by gravitational action, does reveal the aggregate amounts of both negative and positive energy delivered. It follows from the way the basic principle of NEG works that this information is encoded in a still picture of these concentrations without separate consideration of factors such as resulting kinetic energies or heat and pressure within massive astronomical objects. This suggests that we are indeed looking at a kind of holographic representation.

These findings call for further research and offer the opportunity for further evolvement of string theory and quantum gravity.

16. Dual energy physics beyond NEG and DEC

a) The principle of bifurcation and the challenge for science

NEG has demonstrated that positive energy at its origin arises along with negative energy in a process of bifurcation in 0=-1+1 type fashion. This type of process presents itself as the ultimate energy source of the universe. NEG further demonstrates that a potential for energy does not need to represent positive energy, but may instead, as in the case of gravity, describe the ability of a system to generate positive (kinetic) energy at the expense of negative energy. Finally, NEG establishes a close relationship between negative energy and space.

These newly discovered principles create a need to reevaluate fundamental energy related concepts in other areas of physics and raises the challenge to identify and formulate interactions involving negative energy beyond gravity.

b) Particle physics and quantum field theory

This challenge is of immediate relevance for particle physics and quantum field theory. The energy concept applied in this area of physics follows the classical mechanical concept of energy being the sum of positive potential and kinetic energies[52]. Nevertheless, within limited scope, concepts of negative energy densities have already been found to provide useful tools in quantum field theory[53].

Dual energy physics suggests that interactions with negative energy are involved in processes from the early phases of the evolution of mass-energy in the universe and may be of ongoing relevance.

A reevaluation under dual energy physics is suggested to include the interpretation of light and other electromagnetic waves. Certain properties of light, exhibit behavior which appears incompletely represented by a concept of positive energy only. First, this includes that no invariant mass of the

[51] See above 9.

[52] This treatment of energy is expressed in the Hamiltonian operator H. The design of the global energy concept in quantum mechanics follows the correspondence principle so that results from quantum physics reproduce classical physics at large quantum numbers, as originally introduced by Nils Bohr (1920) 'Über die Serienspektra der Elemente', doi:10.1007/BF01329978.

[53] Examples include Larry Ford, (2009), 'Negative Energy Densities in Quantum Field Theory', arXiv:0911.3597, and Henning Bostelmann, Daniela Cadamuro, 2015, 'Negative energy densities in integrable quantum field theories at one-particle level ', arXiv:1502.01714v1.

(traveling) photon can be identified. Secondly, the phenomenon of interference, including a canceling out of wave phases in destructive interference. These phenomena rather point to a net zero energy character of the traveling wave, with an interaction between positive and negative energies. While these determinations are up to a comprehensive effort outside the scope of this paper, I am offering one initial suggestion next.

c) Masses of elementary particles from negative energy instead of a 'Higgs Field'

The quest to identify how elementary particles acquire mass has led to significant theoretical work and was eventually followed by great experimental effort at the Large Hadron Collider (LHC) at CERN[54]. Theoretical work[55] had suggested a mechanism[56] for elementary particles to acquire mass based on interaction with an energy field, referred to as the Higgs field. A particle was discovered at the LHC in 2012, that at the time was considered to be consistent with theoretical predictions for a particle associated with the field, the 'Higgs particle'[57].

However, more recently it has evolved that the discovered particle, referred to as the Higgs particle, is much too light to match theoretical predictions[58]. The discrepancy between theory and the measured mass of the Higgs particle at 125 GeV, has been found to be exceedingly obvious with regard to interactions with the most massive top quark, where the Higgs particle may have to be 16 orders of magnitude more massive to match theory[59]. Attempts have been under way to identify additional new

[54] See https://home.cern.
[55] Peter Higgs (1964) Broken Symmetries and the Masses of Gauge Bosons', Physical Review Letters, 13, 508, François Englert, Robert Brout (1964), 'Broken Symmetry and the Mass of Gauge Vector Mesons', Physical Review Letters, 13, 321.
[56] Referred to as the Brout-Englert-Higgs mechanism.
[57] At the Large Hadron Collider at CERN, 2012, press release at https://press.cern/press-releases/2012/07/cern-experiments-observe-particle-consistent-long-sought-higgs-boson, and the 2013 press release, 'New results indicate that particle discovered at CERN is a Higgs boson' at https://home.cern/news/press-release/cern/new-results-indicate-particle-discovered-cern-higgs-boson.
[58] Ana Lopes, 9-2018, 'The incredible lightness of the Higgs', https://press.cern/news/news/physics/incredible-lightness-higgs.
[59] Ana Lopes, 9-2018, 'The incredible lightness of the Higgs', https://press.cern/news/news/physics/incredible-lightness-higgs.

particles such as vector-like top quarks not predicted by the Standard model of physics, that may cancel out effects leading to the discrepancies[60]. No signs for such particles have been found[61].

Yet, this was before the introduction of NEG and the suggestion of a validity of a wider principle of dual energy physics. From a dual energy point of view it is unnecessary at best to assume a positive energy field permeating all of space. To the contrary, the inability of models based on interactions with an assumed field of particular positive energy to deliver observed values of masses for heavier elementary particles points to a fundamental flaw of these models. With specific positive energy giving mass to various elementary particles, models quite naturally break down for heavier elementary particles. A dual energy mechanism based on corresponding amounts of negative energy does not exhibit that type of behavior.

I suggest that rather than through interaction with a Higgs field, elementary particles acquire their masses at the expense of corresponding amounts of negative energy based on particle specific properties.

16. Final remarks

NEG not only transforms our fundamental understanding of gravity. NEG reveals that positive energy has a negative correspondent and demonstrates how energy is naturally interwoven with space. Stunningly, the process of energy creation is still unfolding in today's universe and happening right in front of our eyes.

The discovery of negative energy and a process that creates it leads to the need for a new Dual Energy Cosmological model. The first outline of the new DEC model already demonstrates the power to address a very significant array of the currently most puzzling questions in cosmology ranging from the question of an initial singularity all the way to dark energy. It renders currently prominent single energy cosmological models obsolete and reveals coherent new insights into foundations of the universe.

The lack of understanding of the phenomenon of energy and the struggle to find alternative explanations has been affecting physical sciences in a variety of areas. This opens the door for new concepts of dual energy physics.

[60] ATLAS Collaboration 8- 2018 'Could a new type of quark fix the 'unnaturalness' of the Standard Model?' https://atlas-cern/updates/physics-briefing/could-new-type-quark-fix-unnaturalness-standard-model.
[61] ATLAS Collaboration 8- 2018 'Could a new type of quark fix the 'unnaturalness' of the Standard Model?' https://atlas-cern/updates/physics-briefing/could-new-type-quark-fix-unnaturalness-standard-model, see also their related paper at arXiv:1808.02343 and Ana Lopes, 9-2018, 'The incredible lightness of the Higgs', https://press.cern/news/news/physics/incredible-lightness-higgs.