Negative Matter and Negative Space-Time
A Zero-energy Universe with Bimetric Relativity

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Rev 1: March 2014
Rev 2.1: March 2016
www.j-d-b.net

Abstract

This paper presents a zero-energy model of the universe in which an equal amount of positive and negative energy exist. The negative energy is characterized as having negative mass and experiencing "negative time", being mathematically described using a bimetric relativity framework. The model predicts a so called "negative space" in which negative energy/matter exists in isolation from normal matter, resulting in what has been called a "Twin Universe". Many unsolved problems in physics appear to be easily solvable when viewed through the lense of this model, including the true nature of dark matter and dark energy, how the energy of the Universe can arise from nothing without violating the laws of energy conservation, how the universe can be infinite and flat and still make sense, the cosmological constant problem, the cosmic coincidence problem, the cuspy halo problem, the missing satellite problem, and other unsolved problems in cosmology.

Disclaimer

The author of this paper is not a professional scientist or mathematician. This paper will not include any original mathematical calculations, it will focus on the concepts and ideas necessary to understand the proposed model of negative matter and negative space-time. Many of the concepts presented in this paper have existed for several decades but they are very little known even in the scientific community. The goal of this paper is to examine some of those forgotten ideas and show that when you interpret them in the right way they can be very powerful tools for explaining deep problems in modern cosmology.

Introduction

There are many holes in our understanding of the universe and there are many people trying to fill those holes. This is especially true for controversial theories such as dark matter and dark energy. Therefore it's important to highlight the fact that the model described on the following pages was originally developed with the sole intention of explaining how the energy of the universe could arise from nothing without violating the laws of physics. The other concepts just fall out of the model when you follow the initial postulates to their logical conclusion.

It is extremely important for science to explain how the energy of our universe was created from nothing and it is not satisfactory to say science cannot solve that problem because time didn't exist before the Big Bang. Clearly the energy had to come from some where but we cannot simply say a bunch of energy popped into existence for no apparent reason. The solution must be scientific and self-consistent if it's to be taken seriously, and it shouldn't leave us asking critical questions which cannot be answered in a concise and meaningful fashion.

A Zero-Energy Universe

> *"We were taught that you never get something for nothing. But now, after a life time of work, I think that in fact you can get a whole Universe for free."*
>
> ~ Stephen Hawking, *Curiosity – Did God Create the Universe*

Let us presuppose that an equal amount of positive and negative energy were created during the birth of our Universe and they cancel each other out to produce a zero-energy universe. In other words, if you add the negative energy to the positive energy, you are left with no energy, the same way that -1+1=0. Many prominent physicists such as Hawking and Krauss believe in the idea of a zero-energy universe because it explains why the curvature of the universe appears to be perfectly flat and it doesn't violate any laws of energy conservation.

However it gets tricky when we begin to ask "where is this so called negative energy"? Several different candidates will be examined in this paper but the candidate we will focus on is the most literal incarnation of negative energy, that is to say, negative matter with a negative mass. According to Einstein energy is equivalent to mass, so if negative energy exists then negative mass could also possibly exist, and negative mass should have negative gravity, which should make negative matter easy to detect in experiments because it would repel normal matter.

Negative Energy Candidates

The problem is that negative matter has never been detected in a laboratory. There are some reasons to suspect antimatter has negative mass but it seems to have positive mass according to all the evidence we currently have. One good reason for thinking that antimatter is not negative matter is because when antimatter collides with normal matter they annihilate and release a burst of gamma radiation. However if negative matter were to collide with an equal amount of positive matter they should cancel each other out and produce no energy.

Another effect that people often look to when they want an example of negative energy is the Casimir effect. It is a rather basic experiment in which a force is generated between two flat plates which are placed very close together. The gap between the plates is so small that it restricts the wavelengths of the vacuum fluctuations which can manifest in the space between the plates, which causes a pressure differential. Since there is a wider variety of fluctuations occurring outside of the plates the pressure is higher outside the plates than it is between the gap.

The difference in pressure causes a force which acts to "suck" the plates together. Since the energy density between the plates is lower than the normal vacuum and the force is attractive it is often said that the Casimir force is an example of negative energy. However this appears to be a common misconception, because it is only negative relative to the ordinary vacuum energy. For that reason it can be asserted that the Casimir effect is actually not a real world example of negative energy, it's just a good example used to conceptualize the idea of negative energy/pressure.

Another candidate for negative energy is in fact gravity, or to be more precise, gravitational potential energy. This view has been espoused by Hawking and some other prominent researchers who use it to construct zero-energy models of the Universe. The basic idea is that gravitational potential energy could be negative energy if we assume that the potential energy is zero when the distance between two masses is infinite. A zero-energy universe is possible if the positive energy of the matter is exactly balanced by the negative energy of the gravitational field.

> *"The general expression for gravitational potential energy arises from the law of gravity and is equal to the work done against gravity to bring a mass to a given point in space. Because of the inverse square nature of the gravity force, the force approaches zero for large distances, and it makes sense to choose the zero of gravitational potential energy at an infinite distance away. The gravitational potential energy near a planet is then negative, since gravity does positive work as the mass approaches."*
>
> Gravitational Potential Energy

The first red flag here is the arbitrary choice of when the potential energy equals zero. When I lift an object into the air I'm doing work which requires positive energy, when I let go of the object that energy is converted into kinetic energy as the objects accelerates back down towards the ground. There is no good reason I can't say that the potential energy is zero when the distance is zero, and as I move the objects apart the potential energy grows, but the growth decays at the same rate the gravitational field decays.

In reality gravitational potential energy is very much like the Casimir effect, it's an attractive force created by a potential/difference between two different energy levels. It's not valid to state that the potential energy is a real world example of negative energy because it's only negative relative to your zero point being set at infinity. The way gravity works is still not fully explained by any unified theory so we shouldn't jump to conclusions, but the existence of gravity waves was strongly confirmed at the start of 2016, bringing us much closer to the truth.

Most scientists who believe in the zero-energy universe idea accept the theory that gravity fields hold negative energy and they don't look any further than that, they think it answers all the questions about where the negative energy is located. According to Einstein's mass-energy equivalence principle, all energy has a mass associated with it. We will take a very literal interpretation of this principle and assert that negative energy should have a negative mass, and in that case it doesn't make much sense to say that gravity fields have a negative mass.

Negative Matter in Negative Space

Einstein would say that all energy has a mass, and it's that mass which causes the fabric of space-time to be curved. The path of moving objects is affected by the curvature of space and that is what creates the effect of gravity. Therefore anything with negative mass should cause space-time to curve in the opposite direction compared to normal mass. Using the 2D analogy, instead of space-time bending "down", negative mass would cause it to bend "up". So instead of things "falling into" the gravitational field, they "roll away" and get repelled.

Of course it's much harder to visualize how gravity works in 3 dimensions, let alone how negative gravity works in 3 dimensions. However the 2D analogy still gets the idea across and it still makes it clear that negative mass curves the fabric of space-time into what might be considered a negative dimension. If positive mass causes bumps on the positive side of the 2D space-time surface, then negative mass causes bumps on the negative side of the surface. That negative dimension of space will be referred to as "negative space" throughout the rest of this paper.

Let us now say that positive mass and negative mass must exist on opposite sides of the space-time surface because they each bend space the opposite way. As such, negative mass will only exist in negative space and positive mass will only exist in positive space. However they can interact gravitationally since they are both bending the same space-time surface. These assumptions about negative mass will be proven in a much more robust fashion when bimetric relativity is introduced.

Although no particles are known to have negative mass, physicists (primarily Hermann Bondi in 1957, William B. Bonnor in 1989, then Robert L. Forward) have been able to describe some of the anticipated properties such particles may have. Assuming that all three concepts of mass are equivalent the gravitational interactions between masses of arbitrary sign can be explored, based on the Einstein field equations:

** Positive mass attracts both other positive masses and negative masses.*
** Negative mass repels both other negative masses and positive masses.*

Negative Mass

Using the rules first described by Bondi, it's possible to model the way our Universe would look if an equal amount of negative and positive matter exist. Since negative matter repels positive matter they wont get close to each other but positive matter attracts negative matter and that creates some problems for us, one of which is runaway motion. However just for the moment, let us accept a basic model where negative matter stays away from positive matter and examine the resulting structure such a model would produce.

First of all we know that the positive matter clumps together to form galaxies. The negative matter, being repelled from other negative matter, does the exact opposite thing and remains in a gaseous cloud type state and doesn't form any structures. Now since we are stating that the positive matter stays away from negative matter, there are spherical zones around every galaxy where the negative matter wont reach. In other words, the cloud of negative matter exists everywhere except close to galaxies because it's repelled from positive matter.

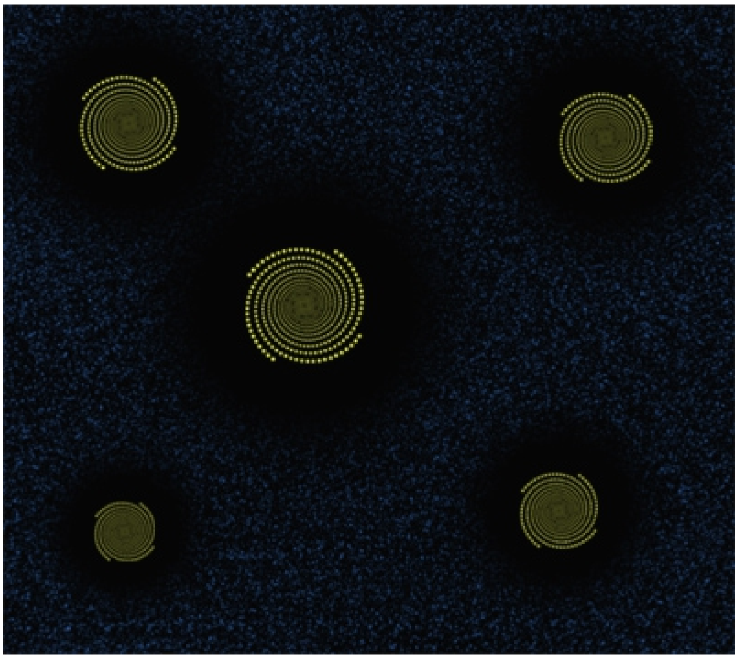

Figure 1a
A 2D visualization of positive mass galaxies (yellow) surrounded by a cloud of negative matter (blue)

Dark Matter and Dark Energy

There are two very important aspects of the structure shown in figure 1a. First of all the negative matter fills all the space between galaxies and it is therefore a perfect candidate for dark energy. Dark energy seems to possess negative energy because it pushes the Universe apart and makes it expand. Secondly, the lack of negative matter around the galaxies makes it appear as though those galaxies have more mass than they really do. When you take away negative matter, it's equivalent to adding positive matter.

Since there is a cavity of negative matter around each galaxy, it strengthens the gravitational lensing effect of those galaxies, a process called inverse gravitational lensing. Since the negative mass only exists in negative space, it can only interact with positive mass gravitationally and we cannot directly observe it. In the real world we do see the amplified lensing effect around galaxies and we say dark matter is responsible for it. This model is saying it's actually a lack of negative matter which is the cause of the strong lensing effect.

It's a nice idea because it perfectly mimics the dark halo model yet avoids many of its downfalls including the cuspy halo problem and the missing satellite problem, which will be discussed in more detail later in this paper. However there are a couple of critical flaws in the model as it has been described so far. The first problem is that the negative matter wont stay away from the positive matter even though it repels positive matter because the large galaxies are made of positive matter and they attract the negative matter.

The second problem is that while this model can explain the overly intense lensing effect we observe around galaxies and galaxy clusters, it cannot explain the flat rotation curves we observe when we measure the rotational velocity of stars orbiting at different distances from a galactic core. Our measurements indicate those stars could only stay in orbit if there was some extra invisible mass holding them in orbit. This is another key reason why dark matter is thought to exist in the form of weakly interacting particles.

Bimetric Relativity and Negative Time

The behavior Bondi first described for negative matter is the same behavior predicted by using basic Newtonian gravity equations with negative inputs. This is most likely not the correct way to calculate the behavior of negative matter and how it would interact with positive matter. Recall that relativistic mass increases exponentially with velocity, and at the speed of light the mass becomes infinite. That is why anything with positive rest mass cannot reach the speed of light, but what about negative rest mass?

According to the logic of relativity, if an object were to reach the speed of light, it would actually begin traveling backwards through time from certain frames of reference. This indicates that negative matter may actually travel backwards through time, and it turns out that logic is probably correct, because in 1970 Jean-Marie Souriau demonstrated in a mathematically rigorous fashion that reversing the energy of a particle is equal to reversing its arrow of time. This leads to new rules for how negative matter behaves and solves the runaway paradox.

First we introduced negative energy by necessity, then negative matter and negative space. Now we have found the last piece of the puzzle by introducing negative time, by necessity. Essentially we seem to have arrived at a description of negative matter which experiences negative space-time. By using bimetric relativity in place of the naive Newtonian approach it's possible to solve the two problems in the old model and it also verifies our assumption that negative mass and positive mass can only interact via the force of gravity.

In 1970, Jean-Marie Souriau demonstrated, through the complete Poincaré group of dynamic group theory, that reversing the energy of a particle (hence its mass, if the particle has one) is equal to reversing its arrow of time.

The universe according to general relativity is a Riemannian manifold associated to a metric tensor solution of Einstein's field equations. In such a framework, the runaway motion prevents the existence of negative matter.

Some bimetric theories of the universe propose that two parallel universes instead of one may exist with an opposite arrow of time, linked together by the Big Bang and interacting only through gravitation. The universe is then described as a manifold associated to two Riemannian metrics (one with positive mass matter and the other with negative mass matter). According to group theory, the matter of the conjugated metric would appear to the matter of the other metric as having opposite mass and arrow of time (though its proper time would remain positive). The coupled metrics have their own geodesics and are solutions of two coupled field equations: [equations removed to reduce snippet size]

The Newtonian approximation then provides the following interaction laws:

** Positive mass attracts positive mass.*
** Negative mass attracts negative mass.*
** Positive mass and negative mass repel each other.*

Those laws are different to the laws described by Bondi and Bonnor, and solve the runaway paradox. The negative matter of the coupled metric, interacting with the matter of the other metric via gravity, could be an alternative candidate for the explanation of dark matter, dark energy, cosmic inflation and accelerating universe.

Negative Mass - Arrow of time and space inversion

Using these new interaction laws, we find that the positive and negative mass both repel each other and that can explain the flat rotation curves because the negative mass surrounding a galaxy pushes against the objects in the galaxy. As an object in the galaxy moves further away from the galactic core it gets closer to the halo edge and experiences an increasingly stronger force trying to push it back towards the core. This can explain why objects rotating at a high speed near the edge of a galaxy can stay in orbit around the galactic core without reaching escape velocity.

Furthermore, it prevents the negative matter from being attracted to the positive matter, which prevents the negative matter from getting close to galaxies and as such allows the inverse gravitational lensing effect to work. As you can see the concept of bimetric relativity has been around for some time. A 1995 paper titled *Twin Universes Cosmology* was one of the first to seriously investigate these ideas and present concepts such as inverse gravitational lensing. Since then it seems not much has happened in this area of research.

In simple terms, what bimetric relativity seems to indicate is that at the moment of the Big Bang, an equal amount of negative and positive energy was created, but because the negative energy is moving backwards through time it actually creates two different "twin universes" which sprout out from the big bang. However the two universes can interact with each other through the force of gravity so they aren't completely isolated from each other and in a sense they are like parallel universes existing next to each other.

However there are still some problems with the model as presented so far, the most obvious of which seems to be that negative matter now attracts negative matter with the new rules, and that seems to prevent the even distribution of negative matter that is required to explain dark matter and dark energy. However it turns out there may be a very elegant, albeit sophisticated, method for solving this problem. According to some research conducted last year if negative mass does exist it should take the form of a super fluid:

> *Nobody knows whether negative mass can exist but there have nevertheless been plenty of analyses to determine its properties. In particular, physicists have investigated whether negative mass would violate various laws of the universe, such as the conservation of energy or momentum and therefore cannot exist. These analyses suggest that although the interaction of positive and negative mass produces counterintuitive behaviour, it does not violate these conservation laws.*
>
> *Cosmologists have also examined the effect that negative mass would have on the structure of space-time and their conclusions have been more serious. They generally conclude that negative matter cannot exist because it breaks one of the essential assumptions behind Einstein's theory of general relativity.*
>
> *Today, Saoussen Mbarek and Manu Paranjape at the Université de Montréal in Canada say they've found a solution to Einstein's theory of general relativity that allows negative mass without breaking any essential assumptions. Their approach means that negative mass can exist in our universe provided there is a reasonable mechanism for producing it, perhaps in pairs of positive and negative mass particles in the early universe.*
>
> ---
>
> *The crucial breakthrough by Mbarek and Paranjape is to show that negative mass can produce a reasonable Schwarzschild solution without violating the energy condition. Their approach is to think of negative mass not as a solid object, but as a perfect fluid, an otherwise common approach in relativity.*
>
> *And when they solve the equations for a perfect fluid, it turns out that the energy condition is satisfied everywhere, just as in all other solutions of general relativity that support reasonable universes.*
>
> Cosmologists Prove Negative Mass Can Exist In Our Universe

This basically solves our whole problem with the negative matter clumping together because it forces the negative matter to remain in a plasma type of state. If there were large clumps of negative matter such as negative stars we would notice their gravitational effects, so there's more than one reason we don't want the negative matter to clump together. Modeling the negative matter as a fluid also had the added bonus that many physicists already like to model dark energy as a super fluid they call the "dark fluid".

The overall idea is that positive matter clumps together and forms galaxies with structure whereas the negative energy remains in a fluid/plasma state and doesn't form any large structures. Since the negative matter/fluid is gravitationally repelled from the positive matter you end up with cavities in the negative matter/fluid where the positive galaxies are located. This creates the inverse gravitational lensing effect we normally attribute to dark matter. The negative energy filling the space between all galaxies causes space to expand between the galaxies and explains the expansion of space which we normally attribute to dark energy.

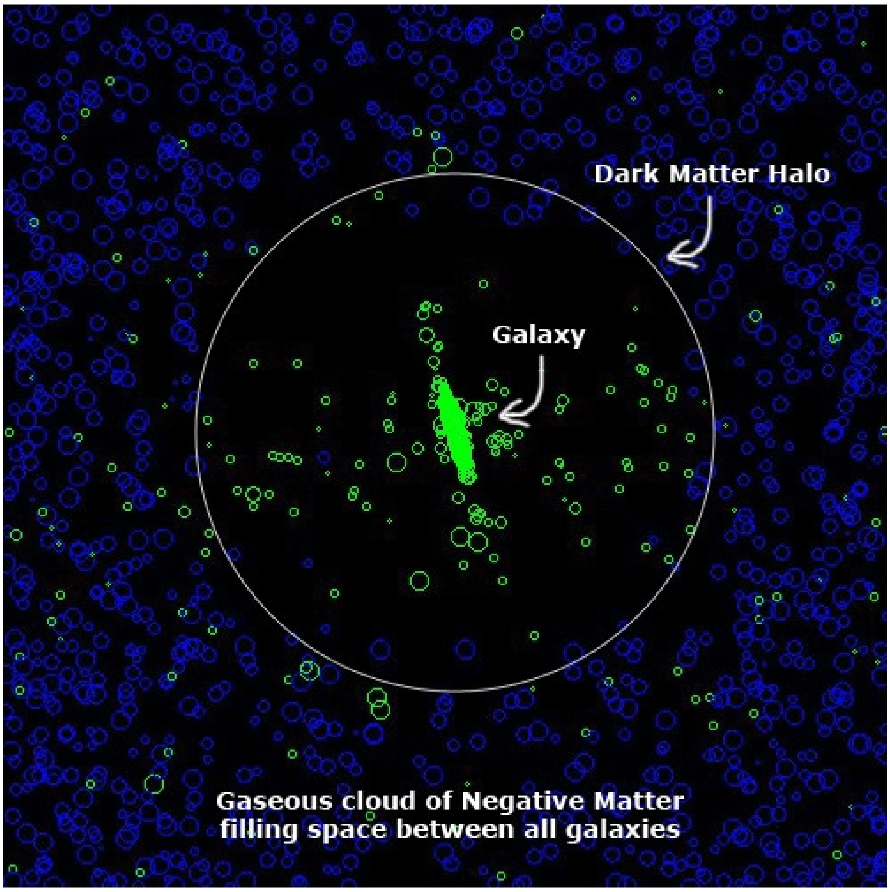

Figure 2a
Result of a simplified 2D simulation
Positive mass yellow, negative mass blue

Birth and Formation of the Universe

According to our most recent observations and calculations, the Universe appears to be perfectly flat. It could be so large that we cannot detect the curvature but there are many reasons to suspect it's perfectly flat, including the very important fact that only a flat universe can be a zero-energy universe. When an equal amount of negative and positive energy exist, the universe has no curvature. Therefore a flat universe is really the only universe which can come from nothing and it's the only type of universe which will fit our model.

The standard Big Bang theory says the Universe began as a singularity and then several complex theories are used to explain how that singularity was transformed into the large scale isotropic and homogeneous structure we observe today. If the Universe is perfectly flat then that also means it's infinite because it will never curve back in on its self. This presents another problem, because explaining how infinite flat space-time can arise from a singularity isn't exactly easy and it's probably not the right approach anyway.

It may be more valid to conceptualize the Big Bang as a spontaneous release of energy inside of infinite flat space and not responsible for creating all of space-time. Or perhaps it is more accurate to describe the birth of the Universe as a vacuum phase transition process in which an infinite amount of negative and positive energy are released throughout an infinite flat universe. Such a model would probably produce an isotropic and homogeneous structure very similar to what we observe in the real Universe.

The evenly distributed energy would collapse into a web-like structure which makes it possible to explain the cosmic web structure without dark matter filaments. Many computer simulations which attempt to simulate how the universe evolves skip the inflation part of the process, they just start with all the matter evenly spread about a 3D cube and then they let it collapse. This may indicate there actually was no inflation stage and the energy started out evenly distributed, then collapsed to form structures over time.

There are several ways our Universe could have started but the goal of this paper isn't to focus on which theory is correct. However, it's pretty clear that the singularity-inflation model isn't compatible with an infinite flat universe and we need some other model to describe how it started. The notion of our Universe being a closed bubble of space-time seems to be a very outdated model and there's no reason we should be so attached to the classic Big Bang theory, other theories exist and they merit attention too.

The Cosmological Constant Problem

> *A major outstanding problem is that most quantum field theories predict a huge cosmological constant from the energy of the quantum vacuum, more than 100 orders of magnitude too large. This would need to be cancelled almost, but not exactly, by an equally large term of the opposite sign.*
>
> Dark Energy

Quantum theory predicts that empty space has an energy due to vacuum fluctuations and the Casimir effect is evidence that it really happens. Based on these facts some researchers made a logical assumption, they said that the cosmological constant must be definable as vacuum energy, because vacuum energy would fill the entire universe and the energy density would never drop because when you create new space it also creates more vacuum energy along with it, meaning it cannot be diluted and it remains constant.

The basic idea is that vacuum energy is dark energy. The problem however, is that when you actually attempt to calculate how much vacuum energy must be contained in our universe it's more than 100 orders of magnitude too large, and if the cosmological constant were actually that large our universe would be expanding much faster. The generally accepted way of solving this problem is to introduce a new type of energy which cancels out most of the vacuum energy but leaves just the right amount to produce the expansion of the universe.

In order to exactly cancel out all the vacuum energy and leave just the right amount would require fine-tuning of about 1 part in 10^{60}. Obviously this is an unsatisfying ad-hoc fix to make the theory consistent, there is no explanation for what this huge opposite term needed to cancel out the vacuum energy could possibly be. In order to explain dark energy they've had to introduce some kind of "anti-dark-energy" which is even more mysterious than dark energy its self and requires a completely ridiculous level of fine-tuning to work.

It was once believed the universe would end in a "big crunch" because the gravity of all the mass in our universe would slow down the expansion and then reverse the expansion and eventually pull everything back into a singularity or some such thing. Dark energy behaves in the opposite way to normal energy/matter, it behaves as if it has negative gravity because it pushes the universe apart and causes it to expand. This is how we know dark energy must possess negative energy, positive dark energy would pull things together.

Vacuum energy is thought to consist of virtual particles which only exist for a very short period of time. Put simply, the reason why virtual particles are thought to contribute a negative energy factor even though they have a positive mass is because they are said to "borrow" energy from the Universe and so they have an energy "debt", giving them a negative energy status. For the purpose of the model presented in this paper we don't really care whether virtual particles possess negative or positive energy because vacuum energy isn't claimed to be the culprit behind dark energy.

The answer to this problem is that vacuum fluctuations are not just creating energy in positive space, there are also negative fluctuations happening in negative space in virtually identical quantities, and they cancel each other out perfectly. This is the huge opposite term physicists are looking for. However if they cancel out perfectly then what remains to cause space to expand? As already explained, the fluid/cloud of negative matter between all the galaxies is the culprit, but is that consistent with the idea of accelerated expansion?

The negative matter should be dispersed and diluted as it causes space to expand, and at first glance this would not appear to be consistent with our observations of an accelerating universe. We must remember however, that the universe only seems to be "accelerating" in size because the space between the galaxies is literally stretching out, not because the galaxies are actually zooming away from each other with a high velocity. This is why all galaxies (beyond a certain distance) appear to be moving away from us.

Any uniform expansion of space will always cause the illusion of accelerated expansion, because the further away an object is, the more space there is between us and that object, and thus there is more space undergoing simultaneous expansion. This means that an object twice as far away as a 2nd object will be moving away from us twice as fast as the 2nd object. Dark energy appears to behave as a cosmological constant but some theories predict the energy density could be dynamic if it changes slowly enough because it will be virtually impossible to detect the change.

The Cuspy Halo Problem

> *"The cuspy halo problem arises from cosmological simulations that seem to indicate cold dark matter (CDM) would form cuspy distributions — that is, increasing sharply to a high value at a central point — in the most dense areas of the universe. This would imply that the center of the Milky Way, for example, should exhibit a higher dark-matter density than other areas. However, it seems rather that the centers of these galaxies likely have no cusp in the dark-matter distribution at all.*
>
> *This remains an intractable problem. Speculation that the distribution of baryonic matter may somehow displace cold dark matter in the dense cores of spiral galaxies has not been substantiated by any plausible explanation or computer simulation."*
>
> Cuspy halo problem

One interesting feature of the dark matter halos we see around galaxies is that they appear to be extremely isotropic, the dark matter doesn't seem to be clumpy at all. If the dispersion of dark matter throughout the galaxy wasn't extremely isotropic it would be possible to actually feel the gravitational effects of dark matter in our every day lives. However we never actually feel this invisible mass floating around, so it must be some sort of extremely smooth ocean of dark matter.

Consider how heavy and pervasive dark matter is supposed to be, if it truly does account for much of the mass in our galaxy it's very hard to imagine how we don't feel the gravitational affects of all that mass unless it's a very static and smooth cloud of dark matter. Even weakly interacting particles exert a gravitational force and in theory WIMPs should be easier to find closer to the galactic core because the dark halo is expected to be denser near the center. However in reality the dark matter seems to be distributed uniformly throughout the entire dark matter halo.

If we realize that the dark matter seems so isotropic in nature because it's actually a gravitational illusion caused by a lack of negative mass then this cuspy halo problem is easily solved. Using the inverse gravitational lensing interpretation it's obvious why dark matter seems to be dispersed so smoothly and why it's seemingly impossible to detect dark matter particles; there is no dark matter, only a cavity of negative matter surrounding our galaxy, and it has virtually the same density throughout the entire cavity, until you get near the edges of the cavity.

The Missing Satellites Problem

> *"The dwarf galaxy problem, also known as the missing satellites problem, arises from numerical cosmological simulations that predict the evolution of the distribution of matter in the universe. Dark matter seems to cluster hierarchically and in ever increasing number counts for smaller-and-smaller-sized halos. However, although there seems to be enough observed normal-sized galaxies to account for this distribution, the number of dwarf galaxies is orders of magnitude lower than expected from simulation. For comparison, there were observed to be around 38 dwarf galaxies in the Local Group, and only around 11 orbiting the Milky Way, yet one dark matter simulation predicted around 500 Milky Way dwarf satellites."*
>
> Dwarf galaxy problem

The problem here is that dark matter models tend to predict far too many dwarf galaxies (aka satellite galaxies) compared to what we see in the real world. Some argue that we simply haven't looked hard enough or that our equipment simply isn't sensitive enough to detect them, but they also make the same arguments about dark matter particle detectors, which have been running for many years and haven't detected anything yet. At some point we have to admit nothing is there to detect but it's not clear when that point is.

If we accept that dark matter particles don't really exist, and they are a gravitational illusion caused by a cavity of negative matter around galaxies, then we know that we will only see "dark matter halos" around galaxies, we wont ever see a dark matter halo without a galaxy unless it has become dislodged in an impact with another galaxy or some other high energy event. That relates to another common problem in cosmology, the problem of explaining how galaxies can become dislodged from the dark halo/core.

The following prediction can be made if we accept that dark matter particles don't exist: if a dark halo were to become completely dislodged from its parent galaxy it would shrink and disappear, and a new cavity should eventually form around the galaxy as it repels the negative matter around it. This process may take too long to directly observe in real time but it also helps explain why the dark matter cores appear to pass through each other undisturbed; it's really just two cavities passing through each other.

The Cosmic Coincidence Problem

> *Why is the energy density of the dark energy component of the same magnitude as the density of matter at present when the two evolve quite differently over time; could it be simply that we are observing at exactly the right time?*
>
> List of Unsolved Problems in Physics

Let us re-frame this "coincidence" from the perspective of the model presented here. If the density of dark energy is exactly the same as the density of normal matter what does that tell us? It tells us that negative matter and positive matter were created in equal amounts, as was predicted near the very start of this paper. It is certainly no coincidence that the densities match, they have always matched and will always continue to match. But then why does negative energy cause space to expand if there's an equal amount of positive energy?

There are two possible answers to this problem. Both reasons relate to the way negative energy and positive energy are distributed throughout space. The first possible answer is that unlike the positive energy which condenses into galaxies, the negative energy is evenly distributed and covers a huge surface area. Because the negative energy exerts a force over such a large surface area of space-time compared to the positive energy it may outmatch the pull of positive energy and cause space-time to expand (between galaxies).

The second, and more robust answer, is that different parts of the universe contain different ratios of negative and positive energy, and we exist in a part of the universe where the density of the negative energy is greater than the positive energy, causing our local universe to experience metric expansion. The CMB patterns may have some correspondence to the variations in density at a time in the early universe. Since we are isolated within the observable universe we are not be able to directly observe or confirm if all parts of the universe are experiencing the same rate of expansion.

Antimatter as Negative Matter

Although there are good reasons to believe antimatter doesn't have negative mass, researchers still aren't entirely certain because it's very hard to test. Even though antimatter doesn't cancel out normal matter the way we would expect of negative matter, they still annihilate on contact. According to some theories in particle physics, such as the Feynman–Stueckelberg interpretation, an anti-particle is equivalent to a particle moving backwards in time. Therefore it may be worth thinking about the implications of antimatter being negative matter.

Another reason we might like to frame antimatter as negative matter is because it may help explain why there seems to be an asymmetry between normal matter and antimatter. If there was antimatter filling the space between all galaxies that would mean there actually isn't less antimatter than normal matter, we just can't detect the antimatter because it has negative mass and is repelled away from the positive mass in our galaxy and almost none of it will come close to Earth unless we artificially create it in a laboratory.

However there are some problems with claiming antimatter has negative mass and exists in abundance between galaxies. First of all antimatter should interact strongly with photons just like normal matter, and if it was filling space between all galaxies then it should be detectable in deep space imagery. Secondly, we should expect to see antimatter colliding with normal matter in some high energy events which would release large amounts of gamma radiation, but we don't seem to observe that type of thing in the Universe.

Conclusion

This paper has presented a theoretical model of negative matter and negative space-time which can be supported by observational evidence and allows us to explain the behavior of dark energy and dark matter and explain how the energy of our universe can be created from nothing. It also allowed us to solve with relative ease several unsolved problems in cosmology. The overall picture developed by this theoretical framework is cohesive, intuitive, and logically elegant, and helps to fill many gaps in our understanding of the universe.

This model makes many bold claims about the nature of dark matter and dark energy which should be testable. Our search for dark matter particles has turned up nothing so far because there probably isn't anything to find in terms of particles. If only a new particle was the solution to everything life would be much easier. At some point we must admit that the theory of WIMPs is incorrect and start looking for alternative explanations. This model is just one of many possible alternative explanations. It may turn out to be wrong but it's worth investigating.

Many of the ideas discussed in this paper were developed many years ago but they remain neglected. Considering that these old ideas have so much power when it comes to explaining large problems in modern cosmology it is worth taking another look at these concepts and applying them in new ways. It seems like elaborate and complex models are being developed to support existing theories, but not enough models are being developed to support the evidence. As the old saying goes, everything should be made as simple as possible, but not simpler.

Relevant Resources

https://en.wikipedia.org/wiki/A_Universe_from_Nothing

https://en.wikipedia.org/wiki/Zero-energy_universe

https://en.wikipedia.org/wiki/Negative_mass

https://en.wikipedia.org/wiki/Dark_matter

https://en.wikipedia.org/wiki/Dark_energy

https://en.wikipedia.org/wiki/Antimatter

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