Title: A Higgs Universe and the Flow of Time

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Abstract

Theoretically considering velocities greater than c implies considering an observer’s past and extends the overall analysis into the complex plane. By using a series of rotations by $i$ in the complex plane, one can create a four-lobed structure of “instants of time,” which together with considering matter and antimatter in the lobes and the +/- sense of the rotation, leads to a Higgs field representation of space and time. A 10x10 metric is developed for this system as well as a generalized spacetime interval.

It is also shown that the Friedmann Equations are consistent with our “Higgs Cosmology” if generalized to a set of coupled equations that connect the forward and backward going solutions. Simple solutions for the forward and backward going universes are presented, and are shown to be consistent with the backward solution providing both inflation and a “cosmological constant” type of dark energy,

Dark matter is also discussed and is hypothesized to be due to the mass of the four “Higgs sectors” as seen through the lens of relativity by an observer in our universe.

A PowerPoint presentation on this work is presented at the end of the report as a supplement.
A Higgs Universe and the Flow of Time

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PREFACE

This report came about due to a variety of reasons, which I think might be interesting to relate before diving into details. You just don’t write a report, even an informal one, without some motivation. Here it is.

First, I am an amateur astronomer, the president of a local astronomy club (Cape Cod Astronomical Society or CCAS), and someone who likes to give talks to the club, local schools, the public, and anyone else about astronomy topics. I thought it might be fun to identify a “research project” on an interesting topic, investigate it in some detail (including some simple calculations), and then cob together a PowerPoint presentation. As I also have a technical background (PhD in nuclear physics and forty-five years as a research scientist in acoustical oceanography), this would let me do a bit deeper dive into an astronomy topic of my choosing. Moreover, I wouldn’t have to worry much about publishing the results, as I would have had to do in my Woods Hole Oceanographic Institution (WHOI) “day job” (from which I am now a retired as an emeritus.) A no-pressure romp into a technical hobby area – ideal!

The topic area I chose to investigate was “Can anything go faster than light (FTL)?” This topic is akin to rat poison as far as publishing in respectable journals is concerned but is ideal for an astronomy club. And besides I had a fascination, as do many of us (thanks to countless FTL novels and movies) with the topic. Who can resist heading off into warp space or hyperspace or whatever label the sci-fi writers gave it? Or back in time? Not me, obviously. Beyond that, there was my personal question of why velocity shouldn’t be looked at continuously from zero to infinity, even if it does wander into the complex plane when you pass c. The complex plane is an old friend to science.
There are many well-known (to scientists) examples of where FTL is considered seriously. Let’s look at a few. The first is when you pass the cosmic horizon. This is defined by Hubble’s Law, which in simple form is $v = Hr$. [Ryden, 2017] When $v$ gets to be $c$ or greater, i.e., at a certain $r$ (as $H$ is constant, at a given time) you are passing the current edge of our visible universe. This is part of everyday life in cosmology, and you will often read in the popular literature that space can expand faster than the speed of light. Second, there are the “virtual particles” that one finds in particle physics [Thompson, 2013] where “off the mass shell” particles exist which seemingly exceed $c$, but only within the limits of the Uncertainty Principle. These latter happen in our everyday universe, and you don’t have to go to its edge to see their effects. Quantum tunneling “faster than light” has also been of great recent interest [Wolchover, 2020]. Finally, there is the Feynman Path Integral, which allows one to seriously consider seemingly crazy spacetime paths that defy the normal strictures. [Zee, 2010 and 2023]

And if you consider two light waves going in opposite directions, the separation between the wavefronts increases at twice the speed of light. This latter example is analogous to a “forward and backward in time” theory that has our universe and an “antiverse” separating at $2c$, which has been published in the peer-reviewed literature. [Boyle et al, 2018] This exploits the fact that relativistic effects are seen “in the direction of the motion.”

My own curiosity was also a motivation. I once complained that my Physics degree only taught me about roughly 5% of what exists (the current estimate of what percentage of common matter and energy exists in our visible universe), and I was really hoping to understand a bit more! Maybe FTL could help with that!

Anyway, those motivations started me thinking in 2022 about the topic, reading many popular and technical books in relevant areas, and trying to perform a few simple calculations that I could show to a general audience, including our club. That initial impulse to do some simple calculations eventually blossomed out into trying to create my own “DIY” universe model, as you will see.

The first very tiny calculation I did involved looking at how space and time transform in Special Relativity, and also at “relativistic mass,” which is a somewhat dated way of looking at the “four-momentum” that includes rest mass and also motional energy. These simple calculations can be done with HS algebra,
which is all that Special Relativity requires as far as mathematics goes. (The concepts underlying SR are the more subtle part.) When I looked at these, and in particular the v>c part of them which contains an important piece called the “gamma” factor, I saw that past c one had an expression displaying negative energy and negative time, additionally with the factor “i” (the imaginary number \(\sqrt{-1}\)) multiplying it. “Negative energy particles traveling backward in time” is a description of antimatter, and the “i” multiplying it put the expression in the imaginary plane, seemingly outside our usual universe as an “extra dimension.” At that point I thought “Has any respectable scientist come up with a “complex plane anti-verse” interpretation in playing with this?” (The older, simplistic interpretation of needing “imaginary mass” for the v>c sector has been a part of FTL’s bad reputation, but we have known for a century that that antimatter exists, and an antimatter interpretation is not unpalatable.)

As a sanity check I “peeked at the answer” by doing a Google search for relevant literature. It turned out that both a Ukrainian scientist and a Perimeter Institute group including a former Stephen Hawking student had published “anti-verse” papers [A. Antonov, 2017; L. Boyle et al, 2018], so at least I had some company. And there were other hits, but these two looked the most promising. Thus, I pushed on further, though without looking initially at much more than the abstracts of the two papers so as not to prejudice my own thinking. I’m a believer in “try it yourself first using simple models.”

What you see in the following are the results, which are actually far beyond my original expectations. What I present may be right or wrong, and though I have tried hard to keep things reasonable, I have not yet subjected the results to scrutiny by any peer reviewed journal. Perhaps I may do so later, if it appears some of these results and conjectures prove worthwhile, though that would have to be in collaboration with someone with real expertise in this area. But no matter how this all turns out, I’ve learned a lot by doing this! Moreover, there may be some pedagogical value in my mistakes.

For now, I’m content to let my imagination run a little wild. When one is looking at “the missing 95% of the universe,” I don’t think it is amiss to think way outside of the usual box, which has so far roped in only 5% of reality. And as even that small part has shown, reality can be pretty strange.
Background on the Big Bang

In considering FTL, one implicitly is looking backwards in time, and in the limit of v having infinite speed, we look directly back to the Big Bang, only without waiting the current age of the universe to see that light. This is a concept sometimes called “NOW” [Muller, 2016]. The early history of the universe and the nature of space and time are intimately related, and so some basic understanding of Big Bang cosmology is a requirement for even making a guess about what is going on in the world of FTL. To understand that I did a fair amount of reading on the subject, and then prepared and gave a public lecture on it, catchily entitled “The Big Bang.” That lecture was/is at the conceptual level, with some nods at the math. I will assume that the reader has some familiarity with cosmology at that level in what follows here and also offer to send that PPT to whoever is interested.

As mentioned, I am trying to look for myself into what FTL would imply, and how this would possibly fit into what science already knows about physics and cosmology. I will describe the details in the sections that follow.

The gamma factor

To begin with, I start with considering Special Relativity (SR) only, in that it is simpler and seems to approximate our “everyday space,” which has a weak gravitational field, rather well. This is a “free space” type of picture, far away from large masses and far from the cosmic horizon. Looking at General Relativity (GR) in the context of the Friedmann Equations will come later.

The first thing one does, and which countless physics undergrads have no doubt done over the past century, is to plot x,t and energy (using the somewhat dated “relativistic mass” m’ which has both rest mass and motional energy incorporated in it) as functions of v. In doing so, I will “turn FTL loose” and let v go from zero to ∞. I will use the notational convenience that v → v’ when v>c.

Additionally, I will use the simple forms: Δt’ = γΔt, Δx’ = γ⁻¹Δx, m’ = γm where γ = (1 − β²)⁻¹/₂ and β = v/c. Using this, you get usual Special Relativity results for Δt’, Δx’ and m’ when v<c, but for v’>c you get:
\[ \Delta t' = -i(\beta^2 - 1)^{-\frac{1}{2}} \Delta t \quad (1a) \]
\[ \Delta x' = i(\beta^2 - 1)^{1/2} \Delta x \quad (1b) \]
\[ m' = -i(\beta^2 - 1)^{-\frac{1}{2}} m \quad (1c) \]

Looking at the equations for space, time and “relativistic mass” (four-momentum), a few things become quickly apparent. First, one has a minus sign in front of the time \((\Delta t')\) and energy \((m')\) terms, which denotes “negative energy particles going backward in time,” which again is another description of anti-matter. Second, there is an \((i)\) factor in front of all of all the quantities, which means they exist in the imaginary plane, or equivalently in an extra dimension 90 degrees out of phase with ours. At first glance this is an antimatter universe at 90 degrees to our own, which I jokingly dubbed a “quadrature anti-verse.” (It’s not really “in quadrature,” as we are not dealing with sinusoids.) We also see that a big player here is the gamma factor, which either directly or inversely multiplies these interesting quantities. It bears further examination.

Let’s look at a graph of \(\gamma\) versus \(v\), as \(v\) goes from zero to infinity. (Fig 1 below). For convenience, if \(v>c\), we will denote \(v\) by \(v'\). I’ll also factor out the \((\pm i)\) multiplier now for clarity and concentrate first on the \((\beta^2 - 1)^{-\frac{1}{2}}\) term. This plot has many interesting features, which we discuss below in a point-by-point manner.
Fig. 1. Gamma versus v, where v ranges from zero to infinity. The x-axis tick spacing in integer multiples of c is done purposely, as these sectors can be interpreted as separate sectors of our universe, as will be discussed.

In considering the γ plot:

1) one has the usual “speed of light barrier for massive particles, and in this case on either side of v=c.

2) one encounters the Planck energy scale when v=c, where “time stands still,” only massless particles can exist, and things are acausal.

3) Given that our universe around the Big Bang evolved from a very high energy state to a lower energy state, the gamma plot suggests that it broke into two sectors; a “real matter” sector, v < c (our usual “present” universe), and an “imaginary axis/antimatter” sector v’>c (which is our universe in the past).

4) The γ plot is a static look at the “present and past.” But we are moving towards the future, and so this graph (and a similar one to be shown soon) needs extending and some “temporal dynamics” to move it along.

5) When one is away from the Planck scale region and on this gamma curve, one is in the realm of Special Relativity (which may be just locally, if the space is significantly curved and one needs GR overall. GR becomes SR over infinitesimally small regions.)

6) The gamma curve for v’>c has an interesting crossover point from greater than one to less than one at 1.41414c (or \( \sqrt{2} c \)). What we can perceive in our universe is perhaps only the γ’ > 1 portion – the rest is seemingly hidden, as it implies masses less than the rest mass. (However, it still should have significance, as will be discussed.)

7) From our point of view, any rest mass (γ = 1 times \( m_0 \)) in our universe would correspond to an antimatter rest mass at a “reflection point” speed of \( v' = \sqrt{2}c \) in the quad-antiverse. This apparent mass would have an energy \( E' = m_0 (\sqrt{2}c)^2 = 2m_0c^2 \).
8) The last point poses the interesting question of “at rest respect to what?” The Cosmic Microwave Background (CMB) rest frame seems to be a good first choice, as our universe and any “anti-verses” had their origin in the Big Bang.

9) Not all particles are at rest in our universe but have a distribution of “peculiar motion” speeds. Moreover, that speed distribution changes over time as does the distribution of particle types.

10) This scheme (as presented so far) generates an extra-dimensional space at which is at 90 degrees to our own. Several schemes have been suggested for how gravity might penetrate between different dimensional (+/- 1) spaces [e.g. Randall, 2005], so this is not an absurd idea to try to account for dark matter, which will be discussed later.

11) This extra dimensional universe could also be taken as an imaginary component of our own universe. We will in fact go beyond just considering an imaginary component in what follows.

12) One interesting possibility that having two orthogonal axes poses is that one might think of rotating them to create temporal flow. This is, in fact, the direction that our more complete model will take. (And they can seemingly be rotated forward and backward in time, as squaring ±ict in the spacetime interval gives the same answer. This is an important consideration.)

Possible Implications of the FTL assumption

The things that the FTL assumption can perhaps comment on are: 1) dark matter (DM), 2) GUT theories and their implications (including the absence of right handed neutrinos, magnetic monopoles and proton decay), 3) the absence of antimatter in our own universe, 4) how cosmology might have to be modified if one includes these seeming antiverses, 5) the CPT theorem, 6) quantum entanglement, 7) dark energy, (DE), 8) the acceleration of the spreading of the universe, 9) inflation and 10) development of structure in the early universe.

I’ll attempt to comment on each topic but will make no claim that what I put out as ideas are firm answers yet. This report is intended to be a sketch of a possible theory, and not a final form.
The other main references – FTL and CPT

What did the other two references I mentioned come up with?

The article by [Antonov, 2017] had one particularly intriguing section for me, as it echoed and extended my thoughts that stemmed from Figure 1. In particular it was his extension of the SR equations to the complex plane, just as I had looked at but in a more general form, that was of interest. It described an infinity of “adjacent universes” based on a FTL extension of the equations of SR. Rather than trying to paraphrase his work, let me quote it directly below. I use ellipses (...) when omitting non-relevant phrases from his paper and any explanatory comments I insert are noted by [comment].

“relativistic formulas can be adjusted as follows:

\[
m = \frac{i^q m_0}{\sqrt{1 - (\frac{v}{c} - q)^2}} = \frac{i^q m_0}{\sqrt{1 - (\frac{w}{c})^2}}
\]

\[
\Delta t = i^q \Delta t_0 \sqrt{1 - (\frac{v}{c} - q)^2} = i^q \Delta t_0 \sqrt{1 - (\frac{w}{c})^2}
\]

where \( q = \downarrow \frac{v}{c} \downarrow \) is the discreet “floor” function of argument \( v/c \).

w=v-qc is the local velocity for each universe, which can take values only in the range \( 0 \leq w < c \),

v is the local velocity measured from our universe, and c is the speed of light.

As shown in formulas (3) and (4) [the above equations], the value q has appeared due to the fact that the velocity of a moving entity v can [seemingly] exceed the speed of light.”

Our normal, matter dominated universe corresponds to \( q = 0, q = 1 \) is a “complex partner” to our matter universe, \( q = 2 \) is a “normal antimatter” universe, and \( q = 3 \) is its complex partner. Once the q value passes four, one is back at our own universe, only at a different time. Moreover, q can have values from \(-\infty\) to \(+\infty\). (Spoiler alert: these four sectors, or equivalently two complex ones, are part of
the Higgs field definition. The usage of separate universes, multiverses, antiverses, etc.is sloppy and confusing, both on his part and on mine, as this is our universe, but at separate times. Better terminology needs to be used, and Higgs lobes or Higgs sectors will be employed). Time is also seen to have extra dimensions, as will be discussed further.

Sadly, the article by Antonov hurt its credibility with the science community due to its garrulous tone and an overstatement of results, and so has been mostly disregarded.

It is also disregarded for another reason which is more scientifically interesting (and to which I will offer a possible counterargument.) It has pointed out [private communication] that the sudden change in reference frame creates a “firewall paradox” where one needs information about the rest of the past universe to be able to change reference frames, which would have to be accomplished by sending out an infinitely energetic stream of tachyons to communicate this information. I will argue (in more detail later) that this is possibly countered by what is called the “EP=EPR” argument, which is well-known in the context of black hole research. [Susskind, 2014]. In any case, it is a serious consideration.

But Antonov’s separation of “universes and antiverses” by a factor of $i^n$, where n=0,1,2...∞, and represents multiples of the speed of light c (see Fig. 1), follows mathematically and does make sense given his extension of Special Relativity.

The next paper (actually papers, with one being an extensive collection of calculations) is the one by the Perimeter Institute group. It proposes an antimatter universe that precedes our “usual” matter universe in time and extends the concept of single universe to being the pairing of a matter and antimatter universe. It potentially solves the problem of why we only see matter in our universe, and also provides an experimentally falsifiable prediction of the mass of a “sterile neutrino” that would provide particulate dark matter. It invokes a bit of particle physics symmetry theory called the “CPT Theorem” (Charge, Parity and Time Reversal) at
the scale of universes. In doing so, it may also avoid the need to invoke “inflation" which adds another hypothetical field to the universe (the “inflaton field”) to explain some of its essential properties. Its attraction for me is not only these properties, as explained by experts in the field, but also that it coincides with the “n=2” solution that my simple FTL view contains. So, there is material in both these papers that was of considerable interest to me.

**My Guess at an “FTL Multiverse”**

First, please note that “FTL Multiverse” in this section title is in quotes. FTL here corresponds to the fact that one would have to travel faster than light to catch up with radiation that was emitted in the past. In the “present sector” of Fig. 1, i.e. v=0c to 1c, nothing exceeds c. And “the multiverse” turns out to be segments of our own universe.

Let me turn now to the model. In my scheme, I consider both a matter universe and an antimatter “antiverse” as the Perimeter group did, but also add a complex conjugate universe component to each. This covers all the multiples of c, not just the even ones. This also gives a similar complex plane diagram (see Figure 2) to Antonov’s, only using n=0,1,2,3 as a basis configuration. I let n→∞ as well, in order to cover all the n*c sectors in Fig. 1 but attach a different interpretation. Specifically, that each group of four sectors represents our universe, but at a different point in time.
Fig. 2. The “quad-universe” or jokingly “Wheel of Time.” Rotation in one direction pushes a universe toward the future, and rotation in the opposite direction looks toward the past. As will be discussed, one full 360-degree rotation corresponds to one unit of time. Our “usual universe” lives on the +t line, the pure antimatter universe considered by the Perimeter Group lives on the -t line, and the complex partners to each universe are at 90 and 270 degrees respectively.

It is worth noting here that, if we translate Fig. 1 to the right by n*c (i.e. look at past times), the “real universe” sector is still at 90 degrees to its neighbor. This shows, as Antonov claimed, that moving by each multiple of c is equivalent to a π/2 rotation.
Let us again look at this scheme on a sector-by-sector basis. The $n=0$ universe (our normal universe) goes from 0$c$ to 1$c$ in Figure 1. The $\gamma$ in this sector is the one we are used to seeing in standard physics books. In the $n=1$ antiverse, there seems to be a “physical region” in the complex plane for $\gamma'$ (again see Fig 1.) which gives relativistic masses equal to or greater than the rest masses we see in our usual universe. That is one of its major attractions. The $n=2$ case was treated by the Perimeter group and gives an antiverse on the negative real time axis, i.e. an antimatter universe that goes backward in time. This gives a time-reversal symmetry to our universe and, as mentioned, has CPT symmetry for the universe/antiverse pair. The $n=3$ antiverse ($i^3 \to 3\pi/2$ in terms of a phase shift) shows the same type of symmetry with $n=1$ as the $n=0$ and $n=2$ universes do with respect to “which is the real matter universe, and which is the antimatter?” The $n=3$ antiverse is also a complex companion to the $n=2$ antiverse in the same way that the $n=1$ antiverse is a companion to our $n=0$ universe. Finally, going past $n=3$ to $n=4$, we come around 360 degrees in phase. We are back in our own “normal matter” universe, but now at a different time.

One would expect that in each of these “multiple of c, FTL” universes Einstein’s speed limit and Relativity would hold, the same as in our present universe. So far as we know, the laws of physics have remained constant in time and will do so in the future. (Not a given, but a reasonable assumption.)

In the sector $n=1$ “physical region,” the equation $(\beta^2 - 1)^{-\frac{1}{2}} = \gamma'$ has solutions where $m_{rel} \geq 1m_0$. In the faster region past there (which also includes all the higher multiples of c), $\gamma' < 1m_0$, and the solution is decaying as one moves farther into the past (or equivalently, distant in space.) If one solves the equation $(\beta^2 - 1)^{-\frac{1}{2}} = \gamma'$, one also has a quadratic equation, resulting in possible positive and negative roots. That is, $(\beta^2 - 1)^{-1} = (\mp i\gamma')^2$. This is a mapping of a spacetime point from the present to the past (and future) no matter what the velocity frame.
The non-static picture – movement in time

“The Wheel of Time” is a well-known metaphor for time, invented long before Robert Jordan’s epic fourteen volume fantasy series. And given Figure 2’s structure, this metaphor almost begs to be explored, if only for the sake of aesthetics.

But there is far more reason than aesthetics. The four Figure 2 lobes of the quad-multiverse are each lagged from each other in time, which follows from Figure 1. Thus, rotating Figure 2 can result in an advancement or retardation of time if one regards the four “spokes” to be part of a circular helical structure.

It is known, by examining the spacetime interval along the null cone, \[ \Delta s^2 = 0 = x^2 - (ct)^2 \] that the advance in time along the t axis matches the advance of wavefronts at c in free space. Given this “continuity equation” type constraint, we can devise a picture that addresses time advancing as the advance of a helical screw, as mentioned by Antonov following a suggestion he attributed to Hawking.

The helical picture is not the only one available, and one can also look at other representations. But we will concentrate on the helical picture, as it seems the easiest to visualize and interpret.

The time advance of the structure can seen through the equations of a circular helix, which are:

\[
\begin{align*}
x(\varphi) &= a \times \sin \varphi \\
y(\varphi) &= a \times \cos \varphi \\
z(\varphi) &= b \varphi
\end{align*}
\]

where \( \varphi \) is the rotation phase angle, \( a \) is the radius, \( a/b \) is the slope, and \( 2\pi b \) is the pitch of the helix.

In the above, we can use our the “continuity” condition that time is also “moving forward at the speed of light” as it is in space, and thus use units which scale \( t=1 \) sec and \( m=300,000 \) km to \( t=1 \) and \( x=1 \), and thus \( c=1 \). Thus \( a=b=1 \),
the slope is also equal to 1, and the pitch is $2\pi$. One can see that an x,y projection of the helical rotation of Figure 2 provides the $(\pm \text{ict})$ part of the metric that we perceive. This is shown in Figure 3 below. This provides no new

Fig. 3. Two helices showing the third dimension of time. One helix moves from the future to the past and the other from the past to the future. The 2-D (x-y plane) projection view of the rotation is shown on the right.

information other than being consistent with our theory. However, it does illustrate the inherent three dimensionality of the time coordinate, which is of interest. I should note explicitly that the coordinates for this helix are $(\hat{i}, \hat{j}, \hat{k})$ where the $\hat{i}$ denotes the real part of the time axis, the $\hat{j}$ is the new imaginary component of time that Hawking envisioned, and the $\hat{k}$ is the apparent direction of time that we see and is given by the usual right and left handed screw rules for cross products.

**Properties of the “Quad-Rotor”**

As an educated initial guess, the quad-rotor is taken to rotate with tangential velocity $c$, with the rotor “radius” and the choice of $v_t = c$ being something we will describe below. This will lead to an interesting angular momentum picture.
We’d also note, even before getting to this picture, that due to the two helicities, the total angular momentum of the system in the time coordinate will cancel to zero. A number of additional points can be made about this helical representation.

First, there is the fact that the three discrete symmetries (P, C, and T) are inherent in our picture. The n=1, 2, 3 lobes are time reversed components, and the Perimeter group paper stressed that aspect for the n=2 case. The (±ict) directions inherent in the picture give the two possible handedness components needed for the parity operator, as shown in Figure 4. And the addition of the complex conjugate lobes, gleaned from Fig.1, gives the charge conjugation operator.

Second, with the added time dimensions, one has a 6-dimensional space (3*time + 3*space), not just 4-D, even though it appears to us like that. Moreover, we should consider the (±ict) to be a “sign bit/factor of two” giving separate forward/backward universes as opposed to being a dimension. This gives us an effective 5x2=10-D space that seems 4-D. Seeing this, and the fact that one has “massive appearing” particles in hidden sectors of the universe, makes one immediately think of superstring theory. Much work has been done in that area, and a translation from the SUSY picture to our quad-sector universe model could be interesting.

Third, one can make an interesting conjecture about spreading laws. If we think of the spreading as being 3-D in space, with the familiar $1/r^2$ law, and being 2-D in time (as our $\hat{k}$-axis “apparent time” is not independent of the other two axes), with a $1/r = 1/ct$ type law, there are interesting consequences. A modified spreading law can possibly shed some light on the fast spreading of the universe near $t=0$ (inflation), its smoother expansion later on (the Hubble Law), and (possibly) earlier than expected formation of large structures observed recently by the James Webb Space Telescope. We will later look at that scenario in some detail.

An interesting case can be made for time spreading $\sim 1/ct$ being a correct choice. If we note that $y = (\tilde{c}/\bar{c}) \int \frac{dt}{t} = \log x$ and that $y=\int e^x \, dx = e^x$, and that the log and exp curves are the inverses of each other separated equidistantly by the line $y=x$, we can conjecture that the decay of the time component feeds energy into
an exponential expansion of the space component, and that the curves balance. Moreover, the $\bar{c}$ can take any value, so that both FTL and slower than light speeds are available, which allows both inflation and the slower Hubble expansion. This will be examined in the context of the Friedmann Equations later on in this paper.

We will hypothesize, as many have before us, that the decay/spread of the Higgs field is the cause of inflation, but also go a bit further. As the $\sim 1/ct$ decay continues forever, I’d suggest that there is a continuing exponential spatial expansion component due to this decay at all times, and that it is what is commonly called dark energy. This overall scenario is a version of “quintessence,” i.e. a time varying cosmological constant (sic). It should be possible to compare this scenario to current models with inflation, a constant cosmological constant, and an accelerating later universe. Again, we will pursue this later in the context of the Friedmann Equations.

Fourth, there is the rotation of our “quad rotor” and the advance of time. We want the observer’s proper time to advance in doing this, which means that we should shrink our rotor to the point that the observer is at. As with the Big Bang, the universe is centered at the point of the observer! When we shrink our rotor down to a point, we are where GR and QM meet, i.e. at the Planck scale.

At that scale, we can come up with an interesting angular momentum picture. In that picture, a simple $L = \vec{r} \times \vec{p}$ argument shows that one gets an $L = pl_{pl}$ type of angular momentum at the point of the observer. These small loops angular momentum are a loop quantum gravity (LQG)/ spinfoam [C. Rovelli and F. Vidotto, 2015] type of result These theories give rise to space, have quantized angular momentum, and many other qualities, but are beyond the discussion here.

It is interesting to try to estimate the units of time that would come from this approach. From freshman mechanics, $v = \omega r$ turns into $c = (2\pi/T)l_{pl}$, which immediately gives $T = 2\pi(l_{pl}/c)$. This is the expected time for Planck scale travel.
time with an additional $2\pi$ factor due to travel around a circle. This $2\pi$ factor cancels against the $2\pi$ factor in the pitch of the helix, giving $T = \left( \frac{l_{pl}}{c} \right)$, as one would initially expect.

Fifth, there is the consideration of the (now very small) quad-universe picture as a single quantum field. As the lobes in it show an angular momentum type nature, we might aptly consider two charged, spin $\frac{1}{2}$ systems (the 0,2 lobes) being added vectorially to give four states represented by (-, -+, +-, +) The (0,2) lobes, our pure matter and antimatter lobes, would be the (-, +) states. The (1,3) lobes would be the mixed (-+, +-) states, which would contain both matter and antimatter components.

Moreover, the mixed states would allow GUT theories to be used, as these lobes would have both left and right-handed neutrinos existing. GUT theories cannot exist in the (0,2) lobes, as they have only left or right-handed neutrinos. But they can exist in the (1,3) lobes of the 5-D space we obtain with an extra dimension of time.

This picture of a possible quantum field arising from a quad-universe seemed interesting enough on its own, but my interest quadrupled (pun intended) when I looked up articles on the Higgs field. Let me just quote the Wikipedia article on this: “The Higgs field is a scalar field with two electrically charged components that form a complex doublet of the weak isospin SU(2) symmetry. Its “Mexican hat-shaped” potential leads it to take a nonzero value everywhere (including otherwise empty space) …” If we identify the charged systems as the matter/antimatter lobes, the isospin doublet as the ($\pm c\text{t}$) which gives the two forward and backward in time universes, and the complex part as the real and imaginary component lobes at 90 degrees from their partners, this looks exactly like our picture above, and it would appear that a Higgs field where our quad-universe model has been leading us. Such a field would extend everywhere, and so describe the entire universe.

Sixth, given that GUT theories can exist, and that our space is 5-D, the quad-Higgs-universe picture is consistent with the so-called “sawtooth mechanism” which predicts the creation of neutrino masses and neutrino oscillation. The
sawtooth mechanism requires a 5-D space to accommodate this mechanism, and by having such a space, one can also create the so-called sterile neutrino, the heavier component of the “light/heavy” sawtooth. In our picture, the sterile neutrino would only appear at the GUT energy scale, which we are not likely to achieve with human technology. However, the Perimeter group, which only invokes the (0,2) sectors, predicts a sterile neutrino at currently measurable energies. Thus, our predictions differ.

Seventh, our “Wheel of Time” picture looks similar to but is not exactly the same as the “loop corrections” seen in Feynman diagrams. Rather, it is a sort of propagator moving particles forward (or backward) in time. This type of propagation is well-known in quantum field theory and is called vacuum polarization. It is also a leading candidate in the community for dark energy. However, this vacuum polarization in our “matter” sector of space alone seems to be far too large to be dark energy by many orders of magnitude.

Eighth, we should note that, even though we have concentrated on the first four “multiple of c” sectors of the velocity, the rest of the velocity curve in Fig 1 past 4*c is still important and contains copies of our quad-universe at earlier times. These sectors perhaps don’t affect our perception of dark matter (as the γ’ curve dips below \( m_0 = 1 \)) but are still part of the imaginary plane. As \( v' \to \infty \), this part of the velocity curve can reach back to the most distant past. If we consider the “wavefunction of our universe” at a given instant of time (a block universe type concept) to contain this sector, it could be a part of how entanglement works. We could be connected to our past, all the way back.

Ninth, there is the (±ict) factor which turns into the \(-c^2 t^2\) term in the null metric. This gives our regular universe where time flows in the forward direction, from the Big Bang towards the distant future. But the backward solution, where time flows backward from the distant future towards the Big Bang also is
mathematically valid. Having these two solutions is necessary to have a 10-D theory, a Higgs field, and right-and left-handed helicities. This point will be discussed further when we consider a possible metric for the system.

Tenth and last, there are both the past and the future to consider. As will be seen in a following section, this is easily incorporated by making the n*c sectors extend from -∞ to +∞.

**A return to the firewall paradox**

As a friend and colleague has pointed out to me [private communication], this Higgs universe picture invokes a “firewall paradox.” We are changing the reference frame of the entire universe, and not just the c ≤ v’ < 2c sector one would assume by rotating that sector by i. (Our “complex rotation” of 90 degrees is of the $\hat{k}$ temporal axis into the $\hat{i}$,$\hat{j}$ temporal plane for each Higgs lobe. Thus, we must look at the entire history of each of the universe lobes, and not just an adjacent point.) We should thus be instantaneously communicating with all the rest of the universe from our 0 ≤ v < c sector point in space and time via tachyons, and reciprocally receiving an infinite number of tachyons from the rest of the universe wondering what we are up to. This influx of tachyons would create a high energy firewall that would discourage such a change of frames. Such a paradox is reminiscent of the black hole information paradox that resulted in the “Black Hole Wars” [Susskind, 2009]. This is especially so as our Planck scale “atoms” of spacetime are essentially at the smallest black hole scale and they also need to communicate with the rest of the universe if they are to form a quantum field.

A possible solution to the difficulty of black holes communicating “outside the light cone” (i.e. across a black hole’s surface to the rest of the universe) was proposed by Susskind and Maldacena and goes by the generic name ER=EPR [J. Maldacena and L. Susskind, 2013; L. Susskind, 2014]. This acronym refers to two classic papers by A. Einstein and his collaborators [Einstein and Rosen, 1935; Einstein, Podolsky and Rosen, 1935]. In the first paper, wormholes are discussed and in the second, quantum entanglement. The ER=EPR conjecture equates the
two and claims that information can be shared between black holes by a combination of entanglement and a wormhole. This would seem to fit our situation.

An interesting question that arises due to this controversy is whether the Big Bang effectively entangled all the particles in the universe. Let me paraphrase some arguments from the [Astronomy Stack Exchange, 2014] about this. “Obviously, all the particles in the universe are not in a single entangled state, as this would lead to absurdities. But a single source like the Big Bang wouldn’t produce a single state, but rather a superposition of a huge amount of quantum states, due to the extremely high temperature and small volume of the early universe. The early universe could be a superposition of all possible quantum states, the wavefunctions of which collapse relative to an observer, regarding the observer as a particular quantum state. This would lead to Hugh Everett’s “Many Worlds” interpretation of quantum mechanics [e.g. Carroll, 2020] and a universal wavefunction.” In this interpretation, rather than encounter a firewall when changing frames by \( i \), the universe simply changes into another possible quantum state. Incidentally, the “Many Worlds” paradigm is becoming a more and more plausible interpretation of quantum mechanics. As a further conjecture of my own, the “backward universe” states could perhaps supply the hidden “Many Worlds” states.

10-D Metric for a Higgs universe

Given that we have come up with a 10-D Higgs universe, it is only fitting that we try to fit it with an appropriate flat space metric. This will not be the usual sort of beast, in that it encompasses: 1) our now 5-D “usual universe, 2) its 5-D complex partner, and 3) two 5x5 “anti-universes” which are the negatives of the above ones. Moreover, this 10-D universe has a forward and backward expression. These correspond to our discussion above.
The metric $M^H$ that this picture produces is:

$$M^H(k,n) = P(k,-k)M^H_{\mu\nu} = (\pm 1) \otimes \begin{bmatrix}
\bar{t}^n \\
  -1 \\
  0 \\
  -1
\end{bmatrix}$$

where $M^H(k,n)$ is the Higgs metric for a given direction of time and instant of time $n$, $P(k,-k)$ tell what the direction of time is (where I’ve used $\hat{k}$ as the third direction of time, orthogonal to the other two which are seen in the (1,1) elements of the $M^H_{\mu\nu}$), and $M^H_{\mu\nu}$ is the four by four matrix that is shown above, and takes the place of the normal Minkowski metric. The sector index $n$ goes from $-\infty$ to $+\infty$.

The spacetime vector that goes along with this is: $\eta = (i^{n+1}ct, x, y, z)$, where it is a 5-D entity because $i^n$ is complex. The $M^H_{\mu\nu}$ system of matrices rotates around from one time on the real axis to the next point in time on the real axis, as is seen graphically in Figure 4.

The M matrix is an unusual beast, but its peculiarities can be explained. First off, the reader might have noted that it has an “n” attached to it, which makes it a function of time. This is due to the rotation of the quad-rotor. However, the metric should be independent of time in the sense that the spacetime interval should be the same at all times (and in all places) in our real SR domain. One can check if this is so by using a range of $n$, including negative $n$, and the new spacetime interval: $(\Delta s)^2 = P(\hat{k}, \bar{k})M^H_{\mu\nu}\eta^\mu\eta^\nu$. When one does this, the spacetime interval is indeed invariant, and one gets the usual $(\Delta s)^2 = [(ct)^2 - (x^2 + y^2 + z^2)]$. It should be noted that to do this, one has to shift the spacetime vector by one time unit, or equivalently multiply by $i$, to put space and time on the same footing. This is a
standard trick that has been used by Hawking and many others and comes about
naturally in this formalism.

The $P(\hat{k}, \bar{\hat{k}})$ factor is also interesting. In our “usual 4-D universe” it is
always one, so that it doesn’t modify the metric. But the (-1) is needed for the
Higgs universe. Also, it changes the (-1,1,1,1) metric into the (1, -1,-1,-1) metric
(with the same diagonal product) in switching from one forward/backward
universe to the other. This puzzling indifference to the sign along the diagonal
becomes resolved as a consequence of being a Higgs universe with a forward and
backward component.

Writing out first four $M_{\mu\nu}^n$ metrics as a bigger matrix which spans one full
WOT rotation (and one time interval as seen on the real axis where we live) is
interesting in that it, as mentioned, reminds one of 10-D superstring theory. (See
Fig. 4) We can directly feel effects from both the n=0 and n=1 quad components,
but not from the n=2,3 quadrants, which are like the hidden dimensions in SUSY.
(The P sign bits are also hidden in that they are not needed in usual theory.)
Fig. 4  Ten-dimensional “quad metric” for n=0 to 3, which gives one full 360-degree loop and then returns one to the real axis, but at a different time. The $P(\hat{k}, -\hat{k})$ factor is one in this example, denoting the “time going forward” universe. The lines between the quadrants are inserted purposely to show that these are actually separate metrics.

**Reversing the Hubble Expansion**

The backward universe solution is also interesting to compare (and combine) with our usual forward time universe. As one solution is contracting in space and time while the opposite $P(\hat{k}, -\hat{k})$ sign is expanding in these, the Hubble laws will be the opposite! If our universe’s Hubble expansion in space and time is $r^3$ (due to both space and time spreading contributing) then the reverse universe contracts as $r^{-3}$.

It is necessary, as mentioned before, that these opposite effects provide a reciprocal, counterbalancing behavior that cancels the dark energy “temporal angular momentum” component, so that the Higgs field is a spin zero system. Let’s look at this in more detail.

In our universe, the Hubble expansion works to pull things apart. When the attraction (due to gravity, the EM force, the strong force, or the weak force) is balanced by the Hubble expansion force at a certain distance $r$, the Hubble expansion stops structure growth, and this is seen in the universes large scale (gravitationally ruled) structure. To show this is fairly straightforward for matter.

We want the “Hubble acceleration” to balance the gravitational attraction, so first we convert Hubble’s law, $v = Hr$, into an effective centrifugal force/acceleration using:

$$a_{cent} = \frac{v^2}{r} = \frac{(Hr)^2}{r} = H^2r$$
When this balances the gravitational acceleration, \( a_{grav} = \frac{GM}{r^2} \), where \( M \) is the total mass enclosed in the volume, we obtain simply:

\[
H^2r^2 - \frac{GM}{r} = 0 \quad \text{or} \quad r^3 = GM/H^2
\]

This has the simple interpretation that the \( r^{-3} \) spreading in space and time is due to the Hubble expansion being balanced against gravity.

The same derivation, only with the opposite sign, works for the “Hubble contraction” and so similarly one obtains:

\[
r^3 = -GM/H^2
\]

So, the contraction has the same nature as the spreading, only backward (and not in heels). This encourages the growth of structure as the universe moves from its dispersed old age towards its incredibly dense beginning. This “push of expansion” and “pull of contraction” would seem to be a good candidate for the force moving our universe forward in time.

We only have knowledge of our universe from the Big Bang to the present (or the opposite, looking backwards). But the future from the present to the end of time (or the opposite looking backward) is hidden from us, and only gradually unfolds as the time progresses. The extrapolation of our future from the present to the end of time can take almost infinitely many intermediate and final statistical mechanical states, and our own state at present is perhaps just one realization “that happened” out of a huge number of possibilities. The same statistical picture arises when looking backward in time. And statistical-mechanically, should one be looking at microstates or the thermodynamic macrostates? Does the total entropy stay approximately constant over time, given this balancing of increasing and decreasing entropy? One sees a very interesting statistical problem arising here.

Having the universe have both low and high entropy states as origin and endpoints may in some sense solve the riddle of “why did the universe originate in a low entropy state when a high energy state is more probable?” It also may indicate a cyclic universe.
We would note that the Big Bang state is a seemingly simpler state. The “end of time” state also seems simple, in the sense of being sparse and possibly even a region where space and time “lose their meaning,” in that there are no longer any landmarks (which are separated by \( r \to \infty \)) nor events (which are separated by \( t \to \infty \)).

But perhaps the endpoints are not so simple, as the dense initial space may be, as suggested by previous discussion, a superposition of a huge number of possible quantum states, and the endpoint may be a Many Worlds superposition of all the possible realizations.

The Friedmann Equations

A logical starting point for many cosmology papers is with the Friedmann equations. They are the historical bedrock of modern cosmology. However, they weren’t the starting point of my little journey, and I don’t think they would have been the best one, anyway. But they need to be addressed, so let me do so now.

The Friedmann Equation, the Fluid Equation, and the Acceleration Equation, designated Eqs. A1-A3, are shown directly below. In these equations, the dot denotes a time derivative, the \( \kappa \) is a curvature factor (set to zero in a flat universe and to 1 in a positively curved one), and \( a \) is the scale factor given by \( R(t) = a(t)r_{\text{co-moving}}, \) where \( r_{\text{co-moving}} \) is the co-moving radius of the universe.
A spherical, homogeneous, isotropic, expanding (or contracting) universe is assumed by these equations. Only two of these equations are independent, and usually it is just A1 and A3 that are considered.

As our foray into the complex plane has led to a somewhat different picture of the universe, i.e. two coupled, counter-evolving systems, we would expect the Friedmann Equations and our approach to them needs to be slightly modified. And indeed, they already have been modified in recent history due to the addition of a dark energy term to our universe. So, what further modifications are needed? One thing that should be done is to go back to the Einstein field equations with a Robertson-Walker metric and re-derive the modified set of Friedmann equations from scratch for coupled Higgs universes. For now, we will just use what modifications that seem necessary to describe the behavior of our own universe, but the full derivation should be done eventually for completeness.

To describes things simply for our universe(s), we need to: 1) consider both roots of the quadratic equation (+t, -t) in the Friedmann Equation, 2) consider both solutions (forward in t and backward in t) of the acceleration equation, and 3) consider the total energy density as a sum of both universes in the Fluid Equation. How to go about this is described next.

**Modifying the Friedmann, Fluid and Acceleration Equations**

The next point to address is how to modify the Friedmann equations for a Higgs system? My suggestions are as follows:

1) The Friedmann Equations A1 and A3 stay in the same basic form, but with an equation for each Higgs lobe including the forward and backward universe solutions for each lobe.

2) In our ordinary universe, a negative pressure is introduced to explain the expansion of the universe due to what is called dark energy. But in our Higgs universe system, this is just the interaction of our normal universe with its “backwards in time” partner universe. So, the Fluid Equation A2 makes more sense if one writes a “lobe by lobe” coupled form for both universes,
i.e.

\[(\dot{\varepsilon}_1) = 3H(\varepsilon_1 - P_2)\]
\[(\dot{\varepsilon}_2) = -3H(\varepsilon_2 - P_1)\]

which when added becomes:

\[(\dot{\varepsilon}_1) + (\dot{\varepsilon}_2) = 3H[(\varepsilon_1 - \varepsilon_2) + (P_1 - P_2)]\]

Thus, energy density and pressure differences between the forward and backward universes drive the energy density flow between them.

**Single Component Universe (matter/radiation) Higgs solutions and their CPT invariance**

Solving the Friedmann Equations for a multi-component (matter and radiation) universe gets complicated but is not so bad when looking at single components. So, we will start out looking at the single components separately. I will follow the treatment by [Ryden, 2017] who very neatly and succinctly summarizes the \(a(t)\) solutions for single component universes in her book.

For the matter component, the \(a(t)\) solution is:

\[a(t) = \left(\frac{t}{t_0}\right)^{2/3}\]

This can be generalized to the “Higgs quad” by multiplying by the appropriate \(t^n\) factors for a forward going universe. Also, doing this in reverse and inverting the sign and parity as well gives the backward going universe. The result of doing this is shown in Table I, just below:
Table I. Matter only solutions of Friedmann Equation for a Higgs universe

For a “radiation only” single component universe, the $a(t)$ solution is:

$$a(t) = \left(\frac{t}{t_0}\right)^{1/2}$$

This can be also generalized to the “Higgs quad” by multiplying, as above, by the appropriate $i^n$ factors for a forward going universe and doing this in reverse and inverting the sign and parity for the backward going universe. One simply replaces the $2/3$ and $-2/3$ powers in Table I by $1/2$ and $-1/2$ respectively to switch from matter to radiation.

These solutions are already very interesting in that they are “lobe by lobe,” with the solution for each lobe having a forward and backward component. They are also CPT invariant between the forward and backward solutions, and also show an apparent matter/antimatter symmetry across the diagonal.

Given the $a(t)$ solutions for single component universes, we can now take their time derivatives to construct the Hubble parameters and also the acceleration parameters for each Higgs lobe. As these time derivatives are simple, we won’t show their details, but rather just present the relevant tables. We will start with the Hubble parameter table, which just involves the calculation of $\left(\frac{\dot{a}}{a}\right)$. The result is:
Table II. Hubble parameters for matter and radiation in the Higgs universe.

These Hubble parameter solutions also have their interesting points. First, the forward Hubble parameter matter and radiation solutions are the same for all four Higgs sectors and are the standard textbook solutions. The backward solutions differ in the sign of $H$, and again are the same for all sectors. This general result from the Friedmann equations agrees with our earlier “matter only” derivation using simple dynamics, which is gratifying to see.

We next turn to the acceleration terms, again looking at matter and then radiation. We obtain the following two Tables:

Table III. Matter acceleration terms for a Higgs universe.
Table IV. Radiation acceleration terms for a Higgs universe.

These acceleration terms also have their interest. The most interesting part to me was that there is a difference in the forward and backward radiative accelerations of each lobe, which when multiplied by the mass of each lobe (presumed to be the mass of the universe) gives a force between the forward and backward universe. Or, if one considers a force per unit area, which would be the surface area of the universe, there is a pressure differential which would tend to inflate one universe (ours) at the expense of shrinking the backward universe. This result is consistent with our “coupled solutions.” The radiative coupling is presumptively from gravity. Also of interest is that the backward radiative term does give an acceleration to our universe, which is decreasing with time, in accord with recent observations. [Wood, 2024]

We will address the “dark energy” part of the solution that the ΛCDM model uses next, though not as a “cosmological constant,” as we are hypothesizing that the backward solutions to the Friedmann equations provide this part of the solution. Specifically, we will discuss how these backward solutions can be incorporated into the general multicomponent solution in our next section.
Multi-component Universes

When considering multi-component universes, one considers matter (including dark matter), radiation, and dark energy. Radiation in our present universe is negligible, whereas matter constitutes ~31% and dark energy constitutes ~69%.

Mathematically, one combines these components in a flat universe as:

\[ H^2(t) = \frac{8\pi G \epsilon(t)}{3c^2} \]

where \( H = \frac{\dot{a}}{a} \) and \( \epsilon(t) \) is the energy density due to all the components. Following the derivation found in section 5.4 of [Ryden, 2017], one can transform this into:

\[ \frac{H^2}{H_0^2} = \frac{\Omega_{r,0}}{a^4} + \frac{\Omega_{m,0}}{a^3} + \Omega_{\Lambda,0} \]

where the subscripts r,m and \( \Lambda \) denote radiation, matter and dark energy respectively. The zero subscript denotes the present age of the universe, i.e. our present time. The \( \Omega \)'s denote the dimensionless density parameter, i.e. \( \Omega(t) = \frac{\epsilon(t)}{\epsilon_c(t)} \). Here,

\[ \epsilon_c(t) = \frac{3c^2}{8\pi G} H^2(t) \]

(See Ryden for more detail.) This is the “Benchmark Model” for a flat universe. Stipulating cold (non-relativistic) dark matter for this gives the \( \Lambda \)CDM model.

We see the usual \( a^4 \) falloff for radiation and the expected \( a^3 \) falloff for matter in an expanding universe. The \( \Omega_{\Lambda,0} \) term represents a constant energy density that fills the universe as it expands. This is the “dark energy” characterized by the cosmological constant \( \Lambda \).

Again, following Ryden, since \( H = \frac{\dot{a}}{a} \), multiplying the second above equation by \( a^2 \) and then taking the square root, one obtains:
\[ H_0^{-1} \dot{a} = \left( \frac{\Omega_r,0}{a^2} + \frac{\Omega_m,0}{a^1} + \Omega_{\Lambda,0}a^2 \right)^{1/2} \]

In our picture, the dark energy comes from energy that is being transferred from the backward component universe to ours. Only radiative energy can cross the “Planck barrier” in Figure 1, so that we are looking at a backward moving addition of radiative energy. The “a” factors for this have already been discussed in our previous work, i.e. \( a_{\text{back}}(t) = -i a^{-1}_{\text{forward}} \). So, the “a” factor we saw in the previous equations becomes, for the dark energy component, \((-1)^4 i^4 \Omega_{r,0}^{-1} a^2\). This gives the correct units in the equation above.

So dark energy in our picture is mathematically similar to the ΛCDM dark energy but is actually a “backward radiative” term and moreover is not constant in time!

In Figure 5, we show the magnitude of the \( a_{\text{back}}(t) \) function. It has a sharp peak (almost a singularity but cut off at the Planck scale) near the origin \( t=0 \), and then a very flat decaying tail as time goes on. It is our conjecture that the peak near the origin is “inflation” (with the backward radiating dark energy providing the “inflaton”) and the flat, decaying tail is what is normally termed dark energy.
Fig. 5. Magnitude $a_{back}(t)$ showing inflation and “cosmological constant” dark energy regimes. $t_0$ is set to 1 instead of $\sim 4.0 \times 10^{17}$ seconds for graphical convenience.

The time dependent decay of $a_{back}(t) \sim t^{-1/2}$ provides both similarities to and differences with the standard “inflation plus dark energy” theories. As inflation theory is complicated, I won’t attempt a comparison here. The comparison between using the cosmological constant dark energy and our new theory should be more straightforward, as it mainly involves comparing what the magnitude and e-folding time of the new theory is to the cosmological constant one.

Given the $t^{-1/2}$ law, the e-folding time should go as $e^2$, so that at 380,000 years (recombination), the e-folding time would be 2.8 million years. Given both the length of time and the smallness of dark energy at this time of the universe’s evolution, it seems doubtful that this change in dark energy affected the early development of fine scale structure. But perhaps changes very early on did have some effect.
As to comparing the dark energy in our model to the cosmological constant model, we can use our \( H_{back,r} = -1/2 \ t^{-1} \) result our model gives along with the estimated present value of the age of the universe to get roughly \( 10^{-49} m^{-2} \) as compared to a “textbook” value of \( 1.1 \times 10^{-52} m^{-2} \). This close agreement is not a surprise as the inverse of the present Hubble constant is roughly the age of the universe, a standard result.

Dark Matter

a. Total Mass

In each of my two main references about antiverses, i.e. the Antonov and Perimeter Group papers, a different mechanism for the formation of dark matter (DM) is proposed for the amount seen, which is roughly a bit less than six times the amount of “normal matter and energy” found in our (sector 0) universe. In Antonov’s, he simply adds the mass of six of the infinite number of universes he proposes, each having “one universe (sector 0) mass.” How one might justify or verify this is unspecified, and it does not look like a credible prediction. In the Perimeter group’s papers, a sterile neutrino which can be seen in our sector 0 universe is proposed, along with a definite mass prediction being made. This is a falsifiable prediction, and a search for such a sterile neutrino is indeed now underway.

In my proposed model, the appeal is to the region from \( 1c \) to \( \sqrt{2}c \) where one sees images of our real particle masses in the complex plane of a neighboring sector. For masses at rest with respect to the CMB in our sector, the image mass looks like \( 2m_{rest} \). For moving particles, the relativistic mass at the reflection point is used to give an answer. For massless (but energetic) particles, the answer in both sectors is the energy of the particle, i.e. \( pc \). This was discussed briefly previously.

If we take the Higgs quad to be a single system, as was discussed, then the view from any one component would be of three total neighbors, each of whom see
their nearest neighbor as having roughly twice our universe’s mass. We would thus see $3 \times 2 = 6$ times the mass of our universe due to our quad-neighbors who occupy the same space.

As all the matter in our universe is not necessarily at rest with respect to the cosmic microwave background, and also there is some significant fraction of radiation, we have to correct (decrease) our “six times the mass of our universe” DM number to account for that. This means knowing what the distribution of all the real matter/energy (ruling out DM and DE) in our universe is. This would also imply that in the earliest universe, before the transition to matter occurred, the Higgs system perhaps had only three times our universe’s mass in DM. This, coupled with the timing of when Standard Model matter was created, could perhaps affect the nature of the early universe’s evolution.

Our model thus gives a falsifiable prediction of DM mass, which is actually a reasonably well-known number at this point in time. If the difference from six times the mass of normal matter is within error bounds, and the error in the velocity distribution of matter/energy in our universe is also within a tolerable error, then a useful comparison can be made.

A small, trivial example of how the matter velocity distribution in our real sector would affect things can help our intuition in this case. Let’s look at three cases: 1) $v=0$, 2) $v=c/2$, and 3) $v=c$. For $v=0$, $m_{rel}^{tot}=3 \times 2=6$, as discussed. For $v=c$, $m_{rel}^{tot}=3 \times 1=3$. And for $v=c/2$, we get $v'=1.15c$ and $m_{rel}^{tot} = 3 \times 1.325m_0c^2$. We see that the “reflection point” procedure favors answers closer to two than to 1, as the sector 0 and sector 1 part of the $\gamma$ curve in Fig 1 are not symmetric.
b. Extent of DM

The extent of DM seen is another piece of the puzzle, and also one that we have some experimental data for. Dark matter “halos” are now well-known astronomical objects which provide the gravitational “cocoons” that galaxies and other normal matter structures form within. There is a wealth of data on the mass and shape of these halos, derived from how they affect the evolution and shape of the normal matter structures seen within, as well as from gravitational lensing.

While our work here cannot define the shapes such halos take, it can comment on what the size of the halos should be relative to the normal matter structures it surrounds as a relatively stable partner.

Getting an estimate of the spatial distortion of the DM we “see” from our sector 0 (normal universe) viewpoint is simple, i.e. just use the $\gamma'$ factor from Eq. 1b, i.e. $\Delta x' = (\beta^2 - 1)^{\frac{1}{2}} \Delta x$ and then use the speed distribution we see in the interval $0c - 1c$, assuming that the DM distribution mimics the sector 0 distribution. As I don’t know the distribution in our sector 0, a very simple estimate can be made if we use the assumption as before that the DM is at rest with respect to the CMB. This means using $v'=2c$. For this value, $\Delta x' = \sqrt{2^2 - 1^2} \Delta x = 1.73 \Delta x$. This still leaves the answer for the spread of DM unsolved but is suggestive that it should be larger than the normal matter spread by a factor on the order of 1.75. For galaxy halos, a factor of ~2 is seen, so perhaps this is a real contributing factor.

Matter/Antimatter Asymmetry

The transition in Fig.1 to lower energy from where $v=c$ and $\gamma \to \infty$ represents a phase transition from timelike ($v<c$) to spacelike ($v>c$) in SR, or equivalently from “accessible” to “in the past,” or from our universe to the “antiverse.” Formally, this looks like a $Z_2$ transition, with $v=c$ being the phase transition point/domain wall. In such a transition, the matter/antimatter is supposedly stable on each side, and the sorting factor is the energy/velocity. An example of this is a domain in a magnet.
The asymmetry in our universe is explained in the Perimeter Group’s papers, using the symmetric nature of the system, as is also seen in ours. But if we consider “our universe” only, and not other sectors, then other mechanisms are needed. And it becomes a harder problem to solve. The Big Bang should have produced as much matter as antimatter, but pretty obviously we see mostly matter, with an imbalance of order $10^{-10}$. To explain this solely within the context of our matter-only universe, Sakharov proposed a set of three necessary conditions:

1) Baryon number (B) violation
2) C and CP symmetry violation.
3) Interactions must occur outside of thermal equilibrium.

The first condition can only be satisfied in GUTs and in SUSY and hasn’t been seen. We would argue that it can occur only in the 1,3 sectors that we can’t see. CP violations, and in particular what is called the “strong CP problem” are also regarded as one of the big unsolved problems in physics. One possible solution to it is a new pseudoscalar particle called the “axion.” This particle is very actively being searched for, in part because it is a prime candidate for dark matter, but with no positive results to date. Our model would agree with this negative result.

As to interactions occurring out of thermal equilibrium, that is an easier condition to fulfill. The expansion of our universe is one very clear example.

The gist of this so far is that our Higgs/quad universe theory seemingly explains the asymmetry naturally, whereas “only our universe exists” theories are unverified as regards the phenomena they predict. On the other hand, our theory also lacks a definitive piece of predictive evidence that would confirm it.
Grand Unified Theories (GUTs)

After DM and DE, one of the biggest mysteries in physics is: why doesn’t GUT work? Group theory and symmetry worked amazingly well for energies through the electroweak energy scale, joining the electromagnetic and weak interactions into a single force. And GUT looked like the next logical step in the 1970’s, with the clear aim of uniting the electroweak and strong forces at the next-highest energy scale. Two logical candidate groups, SU(5) and SO(10), were explored, which contained the standard model of particle physics, namely (SU(3)xSU(2)xU(1). They also predicted some new particles which are mixtures of the two forces. All was well and optimism ran high. “But not so fast,” Nature said. “There are a few difficulties to attend to first.” The major difficulties were the following:

1) We have never seen right-handed neutrinos, only left-handed. The famous physicist Wolfgang Pauli joked that “It seems that God is a weak left-hander” referring to only left-handed neutrinos coming from weak interaction experiments. But to have a successful GUT theory, you need to also have right-handed neutrinos.

2) We have never seen proton decay. We all realize that proton decay would be a disaster for us, as our matter universe is mostly made up of hydrogen (a proton and an electron) or ionized hydrogen (just a proton) or molecular hydrogen (two H atoms). And such a decay is predicted by GUT theories which don’t have to conserve baryon number. But luckily for us it is predicted to happen over insanely long time scales, so that we’re not in any immediate danger. Specifically, GUTs predict half-lifetimes on the order of $10^{31}$ to $10^{36}$ years, and supersymmetric models can give up to $10^{39}$ years. For comparison, our universe is estimated to be $1.38 \times 10^{10}$ years old, so we would expect to see very few proton decays. But by looking at large collections of protons such as in the Super Kamiokande water-based Cerenkov radiation detector, decays with half-lives of less than $10^{34}$ years have been ruled out.
out. (As a note, our quad theory resembles SUSY in some ways, but is not the same, so the estimates above do not hold for our theory.) So, as best we know to date, GUT theory’s predictions of proton decay don’t hold up.

3) In the Standard Model (SM), certain particles like electrons and quarks are basic “point” particles with no internal structure. However, GUT theories allow such structure, which would be shown by (e.g.) the electron having an electric dipole moment, where the structure separates the charged components or charge distribution. So, scientists have looked for this structure in electrons. (Quarks are too hard to use, as they are strongly contained, whereas electrons abound.)

The electric dipole moment is defined by a charge times a distance, i.e. $D = qd$, a simple concept taught in basic electromagnetism courses. But measuring the possible dipole moment of an electron is a formidable task, and has only been accomplished with large particle accelerators such as the Large Hadron Collider (LHC), and occasionally by other clever means. Without going into the experimental details, which are not the aim of this MS, the results are that it has to be less than $4.1 \times 10^{-30}$ e-cm, where e is the charge of the electron. So far, a negative result.

4) There are no magnetic monopoles observed in nature. This may be a non-starter, as Alan Guth showed that inflation theory, if correct, cures the monopole problem, if it ever existed. But if they do exist, our theory also says that we shouldn’t see them in our sector of the universe. So, there is no solid verdict here. (As an aside, I really like magnetic monopoles, as they would bring a beautiful symmetry to Maxwell’s equations. But I don’t think that Nature cares much about what I think!)
The list could perhaps go on about there being no evidence for GUTs in our universe. The verdict is still out, but it is definitely not looking so good to chase GUTs, at least in our universe sector. But you can’t prove a negative proposition, so the search goes on.

So where to go? There are many clever analogies for how to go (or not to go) about things. In Conan Doyle’s Sherlock Holmes story “The Adventure of Silver Blaze” the dog not barking in the night was a positive clue. And the old saw about searching under a streetlamp for a lost object because that’s where the light is the brightest also comes to mind.

Our theory, Antonov’s, and the Perimeter Group’s theories all stray far from the “usual universe only” mindset and state that the searches above are likely to be fruitless, sterile neutrinos excepted.

My personal conjecture is that GUTs do exist, but only in the 1,3 sectors of the universe. How one might test this hypothesis other than seeing the negative results above is not evident to me.

More Tentative and Speculative Topics

1. Group theory and symmetry

The particle physics Higgs field seems to me a bit different from the purely spacetime picture that we’ve concentrated on here. In particle physics, the Lie group describing the Higgs field is SU(2), the special unitary group of degree 2, which can be represented by nxn matrices with determinant 1. In our spacetime case, we seem to have the “parent group” U(2), which is the unitary group which can have complex determinants with absolute value 1.

In the Standard Model of particle physics case, a U(1) rotation of SU(2), denoted as SU(2)xU(1), mixes the components of the complex spinor and gives a
U(2) representation. In our spacetime case, U(1) rotations of our U(2) field give the exchange of energy density between the forward and backward solutions and also the flow of time. The +/- sense of the U(1) rotations provides the forward and backward universes.

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2. Lightness of the Higgs particle

One feature of supersymmetry is that substantially heavier superpartners drag the theoretical mass of the Higgs particle upward, in contrast to how light the actual measured particle was (within the expected range, and not in absolute terms!) Our formalism uses the simple symmetry of the particles/antiparticles of the Standard Model being the “partner” particles, so that one does not expect a very strong upward pull, as is observed.

3. Entropy and Conservation Laws

One of the larger mysteries of the universe, as pointed out by Sean Carroll [2020] and others is: why did the universe start out in such an improbable, low entropy state? If our Higgs/dual universe model is correct, then the puzzle goes away – the total entropy of the system remains constant. As the entropy in one universe increases, the entropy in the “backward” universe decreases, with the total system staying constant (which needs proof). If the math coming from the expansion and contraction of the “opposite in time” universes supports it, then all we are seeing is a constant total energy (and entropy) state that was produced by the initial Big Bang decay of a higher energy Higgs state.

Another consideration is the possible conservation of temporal linear and angular momentum, as is indicated by examining Figures 1 and 2. These quantities sound odd, but certainly are implied by such figures.
4. Are the Friedmann Equations adequate without a “Higgs universe”

If the Higgs hypothesis is not true, we still see a “backward universe” from the modified Friedmann Equations, which could be adequate to explain inflation and dark energy. Dark matter would not be explained though.

5. A stroboscopic universe?

One topic of obvious interest (and popular), given the high degree of symmetry of a Higgs field, is the anti deSitter/conformal field theory (AdS/CFT) duality and the possibility that we are living in a holographic universe. Do we have the right conditions for this to hold? Let's look!

One indicator that our backwards universe is anti-deSitter to ours is the "Hubble attraction" we see in that companion, as we described above. This attraction increases in proportion to the range separation in such a way that a ball thrown would fall back to its thrower in the same amount of time no matter how hard it was thrown. This is one aspect of an anti deSitter space. Also, our backward companion has a negative cosmological constant relative to our deSitter space, another condition. Finally, the field theory we have used is our familiar field theory, and not a more exotic variant. So it would seem that the basic conditions are met.

Given that our backward going universe seems AdS/CFT, what else can we say? Well, noticing that the Higgs system is symmetric as regards who is "forward vs backward," our universe should also look AdS/CFT to the backward component. It also has the same field theory and a negative cosmological constant relative to that component.

For a holographic universe, there is one more criterion - having one space being bigger than the other by one dimension. Since we have "five dimensions plus a sign bit" for each universe, this would seem to be a dilemma. However, the "sign bit" for each universe flips from "on to off" as the Higgs rotor rotates in time, so that the spaces flip back and forth from 6/5 to 5/6 as time evolves. This would result in a stroboscopic/holographic universe. It also might explain why there are 11 and 12 dimensional versions of string theory.

Why Believe Any of This?

This MS began discussing what many would regard as an absurd initial assumption, i.e. FTL propagation. But as is well-known, if you consider FTL, you
will just be extending the x, t, and v curves into the complex plane, a usual ploy in physics. By looking at the so-called “gamma” factor that appears in the x, t, and v expressions, and also looking at multiples of c, the speed of light, it can be shown that a picture first proposed by Antonov makes some sense and describes our universe in the past. Moreover, it describes time as progressing in increments that are determined by the Planck length scale and the speed of light. Using these results, one can show that time is basically three-dimensional, and that we are only seeing a one-dimensional representation of it. Moreover, given the factor $(\pm i ct)^2$ in the spacetime interval, one gets two interacting Higgs universes with opposite handedness (or equivalently direction of time flow.) These results depend upon some interesting conjectures to meet the possible “firewall” difficulty, which is a direction that should be pursued.

Further examination shows that our four “multiples of c” sectors constitute a 10-D universe which is composed of four 5x5 sectors, which also form components of a Higgs field. The movement of particles through them in time looks like the Feynman loop correction diagrams, which presents another interesting conjecture to pursue.

The failure of GUT theory effects to be seen to date is also explained, as is the origin of the C, P, and T discrete symmetries. The asymmetry of matter and antimatter in our universe can explained naturally by the symmetry of the system, rather than having to appeal to more exotic mechanisms.

The theory also makes a testable prediction about the total mass of dark matter we can see and gives some guidance about how relativistic effects may affect the spatial distributions of DM that we see. It seemingly can explain the cosmological constant and inflation in a natural way, and also the acceleration of the universe and the newer observations that this acceleration is decreasing.

In short, there seems to be a plethora of things that “jell” in this theory, so that it would be amiss not to give it some further examination. If it is correct, many new doors will be opened. And if it is wrong, I will simply join a large corps of people who have been wrong so far about some of these major mysteries in cosmology.
Where to Next?

The first thing I hope to do is to shore up the weaker points in my theory if possible. Right now, the “firewall” is a major concern and seeing whether entanglement and ER=EPR is a viable solution.

Secondly, I have a personal shopping list of topics that I’d like to explore further. The holographic universe, the AdS/CFT correspondence, black holes, the cosmological horizon, inflation and more are of interest.

Finally, I’d like to find some cosmology professionals to discuss this with. The ideas seem promising, but it is a huge area in which I am a novice, even if I do have a technical background. And if the work does have merit, I’d like to pass it on to someone who will further it. I am older, retired, and don’t have the time available to catch up to this huge field. Simple calculations and speculation are one thing, but a serious research program is quite another.

My Contributions

The possible connection of the Higgs field to cosmology is not new, and a collection of articles (based on a workshop) on “Higgs Cosmology” has already been mentioned [Rajante, 2018]. And the decay of the “Mexican Hat” Higgs potential to give new particles and a universe is a common conjecture for the Big Bang birth of the universe [Mukhanov, 2005].

But the connection of a Higgs field to the basic spacetime “skeleton” of the universe, i.e. empty spacetime and the progression of time, seems to be new. Also, taking the backward solution to the Friedmann equations seriously as a component of the universe (whether via a Higgs field or not) is unusual. Taking the \((\pm i ct)^2\) signs seriously as a clue rather than an oddity was also consistent with the rest of the work. Formulating the Higgs metric, spacetime interval, and modifying the Friedmann Equations into a coupled system also was original, I believe. Suggesting a possible backward universe solution to the problem of why the universe began in a low entropy state is also novel. Suggesting similarities to supersymmetry and loop quantum gravity is another new direction. And finally, suggesting the concepts of temporal linear and angular momentum is certainly novel.
These admittedly are “odd duck” concepts, and things that a professional in the area would be very cautious about throwing on the table. But as an amateur trying to “throw the net wide” as I said originally – why not consider them?

Acknowledgements

I’d first like to thank my wife Chris for putting up with my “hobby paper” over the past two years I get a bit carried away with my hobbies, and she tolerated this and even encouraged me!

Second my thanks to my friends and colleagues who looked over the various versions of the talk/paper. And to Art Newhall and Natalie Renier, who helped with the graphics, something I have no talent for whatsoever.

Third, I’d like to thank WHOI AOP&E Department Chairman Dr. Andone Lavery for supporting the graphics and allowing me to submit this report to our WHOI archival reports system. I think it fits in as “scientific outreach” to the WHOI community and the public, which is part of an Emeritus Scientist’s charge. Just getting people excited about the various aspects of science is a useful task, whether you’re an oceanographer or a cosmologist.

Fourth, I’d again like to thank those who write popular science articles and books. In looking to gain an overview of what’s going on in complex fields where one is an outsider or newbie, such articles are invaluable. And that is to say nothing of their great value in educating the general public.

Fifth, I’d also like to thank those who write textbooks, which are very large undertakings, but of great importance when done well. I will admit to Ryden’s, Carroll’s, and Zee’s textbooks being personal favorites.

Finally, I’d like to thank the many people whose ideas this rather informal manuscript has cited. Alexander Antonov’s work, while written in a way that likely put off many scientific readers, contained the extension of SR into the complex plane and 3-D time. And Stephen Hawking was one of the first scientists to champion time having extra, complex dimensions. Neal Turok has been one of the main pioneers in “alternate universe” theories, and his antimatter universe and emphasis on CPT are two of the basic components I used. The idea that the Higgs
field may be the “inflaton” responsible for inflation is an old one, due to many in the scientific community.

So, while my work may advance the overall picture, by tying time to a Higgs universe, the previous ideas are certainly not new ones, and need the proper ascription. I hope I have given appropriate credit where it is due, and also have not misrepresented people’s work. If there are such miscues, my apologies! They certainly weren’t intentional.

References

The references here are in a slightly unusual format, in that this is a “sketch” paper, originally (and still) intended as background for a club lecture for CCAS, and not even close to the standard of what you would submit to a science journal. So, I used my own format and broke the references into categories. Some of these categories and references wouldn’t pass muster for peer review, but I read them, they were quite useful, and so they are included. Popular books, articles, and Wikipedia often present basic concepts and assumptions far more clearly than advanced books and research articles. The “soft” literature should be generally praised for what it accomplishes in promoting science rather than looked down upon.

A) Texts

10) Adrian Zee, “Quantum Field Theory as Simply as Possible.” Princeton University Press. (2023)

B) Popular Books


C) Technical Articles
36) [https://astronomy.stackexchange.com/questions/1727/is-everything-quantum-entangled](https://astronomy.stackexchange.com/questions/1727/is-everything-quantum-entangled).
D) Popular Articles


E) Wikipedia Articles Used

45) Baryon Asymmetry
46) Chirality (Physics)
47) CPT Symmetry
48) Cosmological Constant
49) C-Symmetry
50) Dark Matter Halo
51) Gyorgi-Jarlskog Mass Relation
52) Grand Unified Theory
53) Helix
54) Heterotic String Theory
55) Higgs Boson
56) Higgs Mechanism
57) Inflation (Cosmology)
58) Path Integral Formulation
59) Propagator
60) Proton Decay
61) Quaternion
62) Quintessence
63) Rotations and Reflections in Two Dimensions
64) Seesaw Mechanism
65) Sextic Equation
66) Sterile Neutrino
67) Weak Isospin
68) Strong CP Problem
69) Supersymmetry
70) Vacuum Energy
71) Zitterbewegung

Short CV

Dr. James Lynch obtained his B.S. in Physics from the Stevens Institute of Technology in 1972 and his Ph.D. in Physics from the University of Texas at Austin in 1978. He currently holds the position of Senior Scientist Emeritus at the Woods Hole Oceanographic Institution. Dr. Lynch is a Fellow of the Acoustical Society of America (ASA), a Fellow of the Institute of Electrical and Electronics Engineers (IEEE), former Editor-in-Chief of the IEEE Journal of Oceanic Engineering, and current Editor-in-Chief of the Journal of the Acoustical Society of America. He is recipient of the Walter Munk Award (2009), the Oceanic Engineering Society Emeritus Award (2019), and the ASA Gold Medal (2021). His primary hobby is amateur astronomy, and he is the current president of the Cape Cod Astronomical Society. He is also a (returning) amateur pianist relearning Chopin’s A-flat Ballade and Mozart’s K332 Sonata, among others.
PPT Presentation (March 1st, 2024 – has been evolving since then)

SLIDE 1

A Higgs Universe and the Flow of Time

Jim Lynch
President Cape Cod Astronomical Society
Sr. Scientist Emeritus WHOI
EIC Acoustical Soc. Am. Publications
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SLIDE 2

Disclaimer!

• This is a talk by a “serious cosmology hobbyist” – Professionally, I’ve done ocean acoustics for the past 47 years.
  • But I did take graduate courses in GR, QFT, group theory, and particle physics and also have read quite a lot.

• This talk started out as a “fun topic” talk for CCAS about FTL (“faster than light”) but evolved into something far more interesting.

• I’m currently working to produce testable results.

• I’m also trying to have the results I’ll show here checked by people working professionally in the area. 

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52
My original idea → Sci-Fi with perhaps a little more Sci.

- Q: What happens when you (conceptually) go faster-than-light (FTL) ???
  - This is a valid conceptual/gedanken question
- A: You are looking into the inaccessible past
  - We “normally” look into the past, as the travel time of any signal (sound, light, matter) takes time to travel from its origin to a receiver.
  - But as the speed of light c is the ultimate speed limit, we can’t exceed it except conceptually.
  - Conceptually, we could outrun the wavefronts of light that all extended bodies emit as blackbody radiation.
    - We would see inaccessible “past times.”
    - These are outside the observers “light cone.”
    - This also defines c as the speed at which time flows!
    - Let’s look at these concepts.

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SLIDE 4

Spacetime – The Final Frontier!

Fig 2 needs permission... Light cone and hyperbolae

\[ s^2 = \Delta r^2 - c^2 \Delta t^2 \]

This is the “spacetime interval”

- This is also the equation for a hyperbola
- In the figure, you are moving 1 or 2 units in spacetime
- This interval is the same in ALL reference frames
- Space changes and time changes between reference frames - but this doesn’t!
• It is an important class of object in relativity – an “invariant”
• Both this interval and the proper time will be important

$$ds = c d\tau,$$

This is the “proper time”.
It is also an invariant!

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SLIDE 5
But, sorry – you can’t go “elsewhere!”

• We live within the “lightcone” – defined by Einstein’s speed limit. $$s^2 = 0$$
• A rocket traveling to the moon within 3 seconds is in a “timelike” cone – its speed is less than c. $$s^2 < 0.$$  
• A rocket traveling to the moon within 1 second is in a “spacelike” region – its speed is greater than c. $$s^2 > 0.$$  
• We don’t have Warp Drive yet, so spacelike “elsewhere” is forbidden to us!

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SLIDE 6
The “metric” – distance A to B. Figure needs permission. Taxicab metric.

• A “metric” is a function that defines the measurement of distance between two points in a space (manifold). It reflects the underlying geometry of the space of interest.
• An illustration comparing the taxicab metric versus the Euclidean metric on the plane: In the taxicab metric all three pictured lines (red, yellow, and blue) have the same length (12) for the same route. In the Euclidean metric, the green line has length $$6\sqrt{2} = 8.49$$ and is the unique shortest path.
• The “metric tensor” is a BIG component of relativity theory. (And there are quite a few of them out there!)
SLIDE 7

The SR Metric Tensor – Figure needs permission

Minkowski and the Spacetime Interval

\[ ds^2 = -c^2 dt^2 + dx^2 + dy^2 + dz^2 = \eta_{\mu\nu} dx^\mu dx^\nu. \]

\[ \eta = \begin{pmatrix} -c^2 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \]

This diagonal matrix describes the flat space of SR - The “Minkowski metric”

This figure needs permission

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SLIDE 8

Being an amateur effort, I’ll keep mostly to Special Relativity (General Relativity gets complicated very quickly)

A “primer” of SR equations is shown to the side. These are simple algebra equations, though the concepts behind them are a bit more subtle.

These equations work well everywhere in the absence of strong gravitational fields, and “at a point” within such fields.

I’ll mostly show SR results in this talk, though some later results will come from GR via Friedmann’s Equations

55
Want to go FTL? It’s complex...

- Going FTL can be done simply by putting v>c in the above equations.
  - This has likely been done by every student who has studied SR.
  - \( \Delta t' = -i(\beta^2 - 1)^{-\frac{1}{2}} \Delta t \)
  - \( \Delta x' = i(\beta^2 - 1)^{1/2} \Delta x \)
  - \( m' = -i(\beta^2 - 1)^{-\frac{1}{2}} m \)
• We see we have negative energy \((m')\) particles going backwards in time \((t')\).
  • Feynman-Stuckelberg (an accepted) interpretation is \textit{antimatter}.

• Moreover, the expressions have an \(i = \sqrt{-1}\) in front of them. So, this is matter in the past that is in a realm (universe?) \textit{at 90 degrees to our own}?!

• Antimatter is well known, and exists to a small extent in our own universe – so why would one invoke another universe (or whatever it is)?
  • Our usual antimatter is on the negative \textit{real} axis, not on an \textit{imaginary} axis.

• Let’s look at a plot of \((\beta^2 - 1)^{-\frac{1}{2}}\) next to see if we can solve this.

Figure for slide 9 is strictly eye candy. Replace.

\textbf{SLIDE 10}

The Gamma Plot

• The gamma and \(\gamma' = (\beta^2 - 1)^{-\frac{1}{2}}\) sectors of the plot below are central to understanding how one might get a “Higgs field” description of the universe (to be explained soon)
• The right-hand part of the plot from 0 to \( c \) is our usual Universe at one place and at one instant of time.
  • This is a standard result and holds for all places and times.
• GR is a “local symmetry” and holds for specific points.

The Dark Side
• The \( v' > c \) part of The Gamma Plot is where the new part of the story comes in.
  • We note in passing that we can plot \( m \) and \( \gamma \) together, as they just scale by \( m_0 \).
• The \( 0 < v < c \) sector is what we can access at any one instant in time. If we exceed \( c \), we “enter the inaccessible past.”
  • But the laws of physics were the same in the past as they are today (and hopefully will be tomorrow.)
  • So, we see that the \( c < v' < 2c \) sector in the past has the same physics as our \( 0 < v < c \) sector now. So, we would see going past \( 2c \) as an additional 90-degree rotation, or \( i^2 = -1 \).

This is our “usual” antimatter sector, on the \( -t \) axis, and not on an imaginary one!
• This argument can be extended infinitely forward and backward in time, so that we have a continuing series of 90-degree (factor of \( i \) ) rotations!
  • There is a “firewall” concern to all this, which we will come to next!
SLIDE 11

Beware the firewall!
Fighting it can take you to strange places!

- It has been pointed out that the 90-degree rotations of the Higgs sectors would necessitate creation of FTL tachyons and produce a “firewall” of energy.
  - The (i) factor sees all of the n*c sectors!
- This is the “black hole firewall paradox” and is famous in relativity research.
- A solution to this has been proposed by Susskind and Maldecena called ER=EPR.
  - Involves entanglement of black holes and wormholes as described in two papers by Einstein.
  - Slight spoiler alert - our Planck Scale “Higgs Atom” is at the smallest black hole scale, so could apply.
  - If this holds, also implies the “Many Worlds” interpretation of quantum mechanics is true.
    - This is becoming a more accepted interpretation.

Figure was eye candy. Replace.
Let’s look at the gamma plot’s implications, only this time as a rotation and not a translation.

The picture on the right shows 360 degrees worth of rotation. It can be extended in time past 360 degrees only by considering either new Riemann sheets or, equivalently, a third axis of time perpendicular to the other two.

- The third axis is the (l.h. or r.h.) cross product of the two axes shown and corresponds to time going forward or backward.
- This is like a pinball machine that lights up at a “new z-axis time” each time the +t lobe rotates 360 degrees.
- This third axis of time is the time dimension that we actually see! (We only see/feel 1-D time.)
- Having the two “forward and backward going in time” states and four “lobes” (or two complex lobes) is part of identifying a Higgs system. Add +/- charges and you’re there.
- And there’s more...

---

3-D Time

- It’s a plot showing the implications of a gamma plot, with a focus on rotation as opposed to translation.
- The plot includes a 360-degree rotation that can be extended in time by considering new Riemann sheets or a third axis perpendicular to the other two.
- The third axis corresponds to time going forward or backward, similar to the concept of a pinball machine.
- This third axis is the time dimension we perceive, as opposed to the 1-D time we are familiar with.
- The plot includes four lobes, two of which correspond to matter universes and two to antimatter universes, with each universe described by specific angles and velocities.
- By adding +/- charges, the system is identified as a Higgs system.
But first, a brief pause for a sanity check

- At this point, when I saw where this was going, I questioned whether I was the only person who was looking at this as some sort of “universe model.”
  - If I was alone, then I’d question whether or not I’d totally missed something obvious.
  - But I wasn’t alone!
  - Neil Turok/Perimeter Institute papers tracked my antimatter lobe, and A. Antonov my interpretation of the multiples of c.
    - Hawking had in fact previously suggested complex 2-D time.
    - Turok was a student of Hawking.
  - So, I was in some good company (see references below)
- Latham Boyle, Kieran Finn, and Neil Turok,
- 121, 251301 (2018)
- Latham Boyle, Kieran Finn, and Neil Turok,
- “The Big Bang, CPT and Neutrino Dark Matter.”
- arXiv 1803.08930, v2. (2022)
- Alexander Antonov, “Hypothesis of Hidden
- Multiverse Explains Dark Matter and Dark Energy.”
- Applied Physics Research, vol. 9, n0. 2 (2017)

Turok picture needs permissions.
A Few More Important Aspects of the “Wheel of Time”

- The WoT has charge, parity, and complex conjugate pair aspects as well as having the four lobes and two possible time directions (on $t_z$ axis - not shown)
- Note that the system should be “charge neutral” due to cancellations.
- Note also that opposite rotation would cancel any temporal “angular momentum” the system had.
  - Similarly for linear temporal momentum in the other picture.
  - This would be a “spin zero,” scalar system.
  - So, what does this have to do with a “Higgs system?”
So, what is a Higgs system?

- “The Higgs field is a scalar field with two electrically charged components that form a complex doublet of the weak isospin SU(2) symmetry. Its “Mexican hat-shaped” potential leads it to take a nonzero value everywhere (including otherwise empty space) ...”
- If we identify the charged systems as the matter/antimatter lobes, the isospin doublet as the \((\pmict)\) which gives the forward and backward in time universes, and the complex part as the imaginary component universes at 90 degrees from their partners, this looks exactly like our picture above.
- There have been serious efforts to tie a Higgs field to the original scalar field that generated the Big Bang (the so called “inflaton.”)
- And there are still efforts in this area, e.g. a conference on “Higgs Cosmology”

So do we have a point, a lobe, a universe, or what?!

- Since we want the proper time for the observer to be the time that flows (at rate c), we must shrink our “lobes/universes” to the spacetime point (where the observer exists).
  - This is similar to saying that the Big Bang happened everywhere, or that you are the center of the Universe (which you are!)
  - This implies that our Higgs field is a Planck scale phenomenon.
  - But, as a field quantity it also exists everywhere in spacetime, so it can be said to constitute a “universe.”
- Implies that the basic unit of time is the Planck time, \(10^{-43}\) sec, or \(\sqrt{\frac{\hbar G}{2\pi c^5}}\). Not a shocker.
- Within a Planck time, we can perhaps treat this “Higgs quad” as a single, unified quantum system.

Figures are two eye candy figures. Replace.
The CPT Theorem and
Our Picture

- One fascination of the “Higgs universe” picture is that it clearly combines the three “discrete symmetries” of nature, C,P, and T.
  - C is “charge conjugation” which reverses the charge of a particle and makes matter into antimatter (and vice versa).
  - P is the “parity” operator, which describes how a particle/system looks after undergoing a spatial “mirroring” operation.
  - T is the “time reversal” operation, which describes what happens to a system if we switch $t \rightarrow -t$.

- The Perimeter Group showed that their matter/antimatter system (the $t$ and $-t$ lobes) was “CPT invariant,” an important consideration.
  - Our Higgs universe, which simply adds the complex conjugate lobes to the Perimeter Group picture, so should be as well.
    - We are Lorentz invariant, do not exceed c, (perhaps) have a unique ground state and are spin zero!!!!

---

Another vote for a Higgs Universe – the Friedmann Equations

- They are a bedrock of modern cosmology, and they need to be addressed!!!

- A spherical, homogeneous, isotropic, expanding (or contracting) universe is assumed by these equations. Only two of these equations are independent, and usually it is just A1 and A3 that are considered.

- They are derived from the full Einstein field equations using a special metric (the FLRW metric), and so are fully General Relativistic.
In these equations, the dot denotes a time derivative, the $\kappa$ is a curvature factor (set to zero in a flat universe and to 1 in a positively curved one), and $a$ is the scale factor given by $R(t) = a(t)r_{\text{co-moving}}$, where $r_{\text{co-moving}}$ is the co-moving radius of the universe.

Alexander Friedmann  The picture of him needs permission

SLIDE 19

How do we adapt the Friedmann Equation(s) to a “Higgs Universe?”

3) In a spatially flat universe ($\kappa=0$), the Friedmann Equation has the simple form of Chrystal’s Equation, which is a first order nonlinear ordinary differential equation (ODE) of degree two.

4) Specifically, given that $\left(\frac{\dot{a}}{a}\right)^2 = H^2$, we obtain, taking the square root:

   $$\dot{a} = \pm H_0 a$$

5) Given that it is quadratic, it has two roots (+/−).

6) Also, given that we are now looking at a complex field picture (e.g. the gamma plot), the solutions should be complex.

7) The essence of the solutions is that one solution is for an expanding universe with time going forward, i.e. our usual universe and the second one is appropriate for a contracting universe with time going backward. Both these universes contain a matter and antimatter component and a matter and radiation component.
• The real part corresponds to our usual universe and the imaginary part(s) corresponds to the “dark energy” component.

• The dark energy solution contains both inflation and the “cosmological constant” region.

8) The Friedmann Equations A1 and A3 stay in the same form, but with an equation for each forward and backward universe solution.

9) The Fluid Equation makes more sense if one writes a coupled form for both universes, i.e.

\[
\begin{align*}
\dot{\epsilon}_1 &= 3H(\epsilon_1 - P_2) \\
\dot{\epsilon}_2 &= -3H(\epsilon_2 - P_1)
\end{align*}
\]

which when added becomes:

\[
(\dot{\epsilon}_1) + (\dot{\epsilon}_2) = 3H[(\epsilon_1 - \epsilon_2) + (P_1 - P_2)]
\]

Thus, energy density and pressure differences between the forward and backward universes drive the energy density flow between them.

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SLIDE 20

“Matter only” universe solution to the Friedman equation

• This solution corresponds to the four Higgs sectors as before, explicitly complex and with the “backward” solution presented as well.

66
• It is a “4-Vector” type solution
• It is CPT invariant as one can quickly verify.
• The real part of our forward solution is the “usual answer” seen in the textbooks
• The complex / backward parts of the solution give the Big Bang inflation, as well as the ongoing “cosmological constant” Dark Energy.

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SLIDE 21

Hubbles Law

• Hubble’s Law, due to cancellations in the $a/\dot{a}$ gives the same $H$ for all the Higg’s sectors but differs in sign for the forward and backward solution “universes.”

\[
\begin{align*}
H_{\text{matter}} &= \frac{2}{3} t^{-1} \\
H_{\text{radiation}} &= \frac{1}{2} t^{-1}
\end{align*}
\]

\[
\begin{align*}
H_{\text{matter}} &= -\frac{2}{3} t^{-1} \\
H_{\text{radiation}} &= -\frac{1}{2} t^{-1}
\end{align*}
\]

FORWARD

BACKWARD

SLIDE 22

Matter and Radiation Acceleration

• In the early 1990’s, cosmologists thought our universe was decelerating due to the matter and energy in it.
• Perlmutter and Schmidt looked at distant Type 1a supernovae and found out it was accelerating instead
  • Picked up a Nobel Prize for that
• Einsteins “cosmological constant” $\Lambda$ became “anti-gravity” / dark energy
• Our backward radiation term is accelerating (at a decreasing rate) and is consistent with Type 1a observations and new findings that the acceleration has been decreasing.
Matter acceleration terms (above)

\[
\begin{align*}
\text{FORWARD} & \quad \text{BACKWARD} \\
\Re \left[ \dddot{a}_m(t) \right] &= -\frac{2}{9} \frac{A}{t^2} t^{-\frac{3}{2}} & \quad \dddot{a}_m(t) &= -\frac{10}{9} \frac{D}{t^2} t^{-\frac{5}{2}} \\
\Re \left[ \dddot{a}_w(t) \right] &= -\frac{2}{9} \frac{B}{t^2} t^{-\frac{3}{2}} & \quad \dddot{a}_w(t) &= -\frac{10}{9} \frac{C}{t^2} t^{-\frac{5}{2}} \\
\Re \left[ \dddot{a}_r(t) \right] &= \frac{2}{9} \frac{C}{t^2} t^{-\frac{3}{2}} & \quad \dddot{a}_r(t) &= \frac{10}{9} \frac{A}{t^2} t^{-\frac{5}{2}} \\
\Re \left[ \dddot{a}_w(t) \right] &= \frac{2}{9} \frac{D}{t^2} t^{-\frac{3}{2}} & \quad \dddot{a}_w(t) &= \frac{10}{9} \frac{A}{t^2} t^{-\frac{5}{2}} \\
\end{align*}
\]

where \( A = t_0^{-\frac{2}{3}} \), \( B = (\frac{t}{t_0})^{-\frac{3}{2}} \), \( C = t_0^{-\frac{5}{2}} \), \( D = (\frac{t}{t_0})^{-\frac{5}{2}} \)

Radiation acceleration terms (above)

\[
\begin{align*}
\text{FORWARD} & \quad \text{BACKWARD} \\
\Re \left[ \dddot{a}_m(t) \right] &= -\frac{A}{4} t^{-\frac{3}{2}} & \quad \dddot{a}_m(t) &= -\frac{3}{4} A' t^{-\frac{5}{2}} \\
\Re \left[ \dddot{a}_w(t) \right] &= -\frac{B}{4} t^{-\frac{3}{2}} & \quad \dddot{a}_w(t) &= -\frac{3}{4} B' t^{-\frac{5}{2}} \\
\Re \left[ \dddot{a}_r(t) \right] &= -\frac{C}{4} t^{-\frac{3}{2}} & \quad \dddot{a}_r(t) &= -\frac{3}{4} C' t^{-\frac{5}{2}} \\
\Re \left[ \dddot{a}_w(t) \right] &= -\frac{D}{4} t^{-\frac{3}{2}} & \quad \dddot{a}_w(t) &= -\frac{3}{4} D' t^{-\frac{5}{2}} \\
\end{align*}
\]

where \( A = t_0^{-\frac{1}{2}} \), \( B = (\frac{t}{t_0})^{-\frac{3}{2}} \), \( C = t_0^{-\frac{5}{2}} \), \( D = (\frac{t}{t_0})^{-\frac{5}{2}} \)

and \( A' = t_0^{-\frac{1}{2}} \), \( B' = (\frac{t}{t_0})^{-\frac{3}{2}} \), \( C' = t_0^{-\frac{5}{2}} \), \( D' = (\frac{t}{t_0})^{-\frac{5}{2}} \)
Inflation and Dark Energy from a contracting companion universe

- Below is the scale factor “a” for our backward-going companion universe. (Scaled to $t_0^{-1/2} = 1$ for visibility). $t_0$ should be $\sim 10^{17}$ seconds when scaled to current age of universe.

- It starts out huge, but contracts quickly (the “Hubble attraction”) and is the coupled input to our universe for inflation and dark energy.

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SLIDE 22

In that we have a flat, Higgs universe, it should have a fitting metric!

- The metric $M^H$ that this picture produces is:
The spacetime vector that goes along with this is: \( \eta = (\pm 1)(i^{n+1}ct, x, y, z) \), where it is a 5-D entity plus a sign bit \( P \) that is needed to specify which direction time is moving in. The \( M_{\mu\nu} \) system of matrices rotates from one time on the real axis to the next point in time on the real axis,

Ten-dimensional “quad metric” for \( n=0 \) to 3, which gives one full 360-degree loop and then returns one to the real axis, but at a different time. The \( P(\hat{k}, -\hat{k}) \) factor is one in this example, denoting the “time going forward” universe. The lines between the quadrants are inserted purposely to show that these are actually separate metrics.
SLIDE 23

Not exactly your usual metric!

- You might have noted that it has an “n” attached to it, which makes it a function of time. This is due to the translation in the gamma figure or the rotation of the WOT. However, the metric should be independent of time in the sense that the spacetime interval should be the same at all times and in all places in our treatment.

- Define new spacetime interval: \((\Delta s)^2 = P(k, \overline{k})M_{\mu\nu}n^\mu n^\nu\).

- One can check if this is time and space invariant by using a range of n, including negative n, and the new spacetime interval. When one does this, the spacetime interval is indeed invariant, and one gets the usual \((\Delta s)^2 = [(ict)^2 + (x^2 + y^2 + z^2)]\) for all n. It works!

- The “quad/Higgs metric” (last figure) also has an interesting property that the backward universe is a “hidden sector” from us and is reminiscent of the hidden dimensions in supersymmetry. (See next slide)

Figure was cute eye candy - replace

SLIDE 24

“Sorta-Super” Symmetry and Loopy Quantum Gravity

- There are interesting similarities to SUSY theory in this “Higgs Universe.”
  - SUSY swaps bosons and fermions to create a new sector of “super particles”
  - Our theory has two complete sectors as well, one with a “Hubble repulsion” (ours, a fermion analogue) and one with a “Hubble attraction” (the backward solution, a boson analogue)
  - Ours also has “apparently heavier” (due to relativity effects) particles in the second, imaginary sector, similar to SUSY theories.
  - Loop Quantum Gravity (loops of angular momentum creating space and time) also look like the rotation of the Higgs sectors at the Planck scale.
    - This may be stretching things but is worth looking at.

Figures of Sheldon Cooper and Leslie Winkle need permissions!
Dark Matter and Dark Energy → my hypotheses

Dark Matter

- The gamma curve for $v'>c$ has an interesting crossover point from greater than one to less than one at $1.41414c$ (or $\sqrt{2}c$). What we can perceive in our universe is only the $v'>1$ portion – the rest is seemingly hidden.

- From our point of view, any rest mass ($\gamma = 1$ times $m_0$) in our universe would correspond to an antimatter rest mass at a “reflection point” speed of $v' = \sqrt{2}c$ in the quad-antiverse. This apparent mass would have an energy $E' = m_0 (\sqrt{2}c)^2 = 2m_0c^2$.

- So, we see our complex “quad neighbor” having twice our universe’s mass/energy. So do the other two lobes, giving $3*2=6$. (This assumes the Higgs field is a unified system.)

- The answer is ~6, with some “proper motion” corrections not discussed here. The corrections should be verifiable, giving a testable hypothesis.

Dark Energy

- In our theory, Dark Energy is the gravitational energy flowing between the backward evolving universe part of the Higgs field and our “normal” forward evolving universe component.

- The coupled Friedmann equations show this explicitly.

Figure was “Dark Matter and Dark Energy” book cover – need new figure or permission.

Conservation Theorems (Can we prove these?)

- Entropy – A huge enigma why the universe we see started out in such a low entropy state! Not what you’d expect at first!
  - But in our model, our universe is increasing entropy while in the backward universe it is decreasing!
  - These might cancel/be inverses to give a constant entropy for the whole system.

- Energy and Momentum (4-momentum)
  - Again, these might be conserved in the “coupled Friedmann equation” universe.

- Angular Momentum
  - The “temporal” angular momentum of the Higgs field seems to cancel/be conserved

- Such theorems may be provable for the overall system! Symmetry of figures suggests this.
Experimental Evidence to Date

- There are two classes – what we do see and what we don’t see.
  - What we see/observe is dark matter and dark energy
    - We have a pretty good handle on how much we see of each based on their effects.
    - But we have no solid explanation of what they are to date
  - What we don’t see is, well, quite a lot
    - Right-handed neutrinos
    - Sterile neutrinos
    - GUT theory effects
    - Structure in point particles (electrons, quarks)
    - Proton decay
    - Magnetic Monopoles
    - Any non-SM particles!
  - My theory says we shouldn’t see any of these – but is a negative proof, not compelling.
    - But if we DO see them, my theory is inadequate or wrong.

Figure was eye candy on “Know what you know and do not know” – get permission

Possibly Testable Items (work in progress)

- Big Bang onset properties (matter and radiation differences)
- Matter/DE dominance crossover point (via matter and radiation evolution differences)
- Hubble tension (via matter and radiation evolution differences)
- Is acceleration of universe expansion increasing or decreasing?
- Amount of DM (via proper motion corrections to ~6)
The picture to date – what’s old, new, and missing

- My picture is strangely “non-exotic.”
  - No FTL, simple math, and no exotic new particles – just our SM ones!
  - Higgs field is a known entity
  - Antonov and Turok’s group anticipated complex solution of SR and an antimatter universe.
  - Even ER=EPR and Many Worlds are older theory.

- My contributions are:
  - To identify time flow with a Higgs field
  - To take the quadratic coupled and 2nd order DE nature of the Friedmann Eqs. seriously
  - To take the \((\pm i c t)^2\) signs seriously
  - To formulate the metric, spacetime interval, and modified Friedmann Eqs.
  - Propose testable hypotheses for DM, DE.
  - Suggest possible explanation for entropy enigma
  - Suggest similarities to supersymmetry and loop quantum gravity/spinfoam theories.

- What’s missing (lots) includes:
  - A far more formal quantum field theory approach
  - Conservation theorem proofs

Full modeling efforts (not just a toy universe).

--------

SLIDE 30

Selected References

A) Texts

6) Viatcheslav Mukhanov, “Physical Foundations of Cosmology.”

B) Popular Books

C) Popular Articles

D) Technical Articles

Figure is picture of books – get one with permissions

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SLIDE 31

75
A Higgs Universe and the Flow of Time

This report should be cited as: Woods Hole Oceanographic Institution Technical Report, WHOI-2024-02

Theoretically considering velocities greater than c implies considering an observer's past and extends the overall analysis into the complex plane. By using a series of rotations by i in the complex plane, one can create a four-lobed structure of "instants of time," which together with considering matter and antimatter in the lobes and the +/- sense of the rotation, leads to a Higgs field representation of space and time. A 10x10 metric is developed for this system as well as a generalized spacetime interval.

It is also shown that the Friedmann Equations are consistent with our "Higgs Cosmology" if generalized to a set of coupled equations that connect the forward and backward going solutions. Simple solutions for the forward and backward going universes are presented, and are shown to be consistent with the backward solution providing both inflation and a "cosmological constant" type of dark energy.

Dark matter is also discussed and is hypothesized to be due to the mass of the four "Higgs sectors" as seen through the lens of relativity by an observer in our universe.

A PowerPoint presentation on this work is presented at the end of the report as a supplement.

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Higgs field

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time
dark energy

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