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# Our Symmetric, Complex, and Translucent Universe

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This paper seeks to fill in the gaps of modern relativistic Cosmology by utilizing the total symmetry between space and time dimensions and re-interpreting the scale factor of the Universe as a gravitational potential generated by the mass/energy of the entire Universe as a whole. The gradient of this potential is along the cosmological time dimension through which the Universe is falling. This gradient gives us an arrow of time, we find explanations for why the Universe began expanding and why the expansion is accelerating without the need for a Cosmological Constant. In a finite time, the gradient will point in the opposite direction of time turning the expanding Universe into a collapsing one where it is shown that when placing the Schwarzschild metric in the dynamic Cosmological background, gravity becomes repulsive and things like would-be Black Holes become White Holes. The model naturally describes a Universe and an anti-Universe (consisting of antimatter) moving in opposite directions of time that collide at the end of collapse, annihilating and subsequently pair producing two new Universes as the cycle begins again. It is shown that the model's Hubble diagram fits the currently available supernova and quasar data. It is found that Dark Matter can perhaps be understood as ordinary matter that is not connected to us with null geodesics.

**Keywords:** Cosmology; General Relativity; Schwarzschild; Black Holes; Dark Energy; Dark Matter

**Statements and Declarations:** There are no competing interests

**Data Availability Statement:** All data generated or analysed during this study are included in this published article [and its supplementary information files].

## I. MOTIVATION AND ROADMAP

The current model of cosmology is based on the FRW metric, which, under the flat space assumption, is a flat space metric in spherical coordinates whose space-like dimensions are scaled by a time-dependant scale factor. What is notable here is that for a Universe with a non-accelerating expansion, the FRW model makes the same predictions as a spherically symmetric cosmological model based on Newtonian gravity. But the expansion of the Universe is now known to be accelerating. To accommodate this acceleration, the cosmological constant is introduced into the field equations which is assumed to give empty space a pressure that creates an accelerated expansion. The problem with the cosmological constant is that it is just a measured number whose value is heretofore unpredictable via any currently existing theory, making the true underlying nature of the accelerated expansion a mystery.

Another notable feature of the FRW metric is that it models the Universe as a continuous fluid. While this approximation might work well in the early Universe where the matter is more evenly spread, it becomes less accurate over time as concentrated pockets of matter become more dispersed and the continuous fluid assumption starts to break down, requiring the use of the Cosmological Constant to correct for that. It is also curious that this fluid model curves space via the scale factor, but leaves the time dimension completely uncurved. This is curious because we know that for a finite distribution of matter/energy, both space and time are curved, yet the FRW metric seems to suggest that the infinite matter and energy of the Universe has no effect on the curvature of the time dimension.

The origin of the scale factor in the FRW metric is also unclear. The metric provides no reasoning for why the Universe began expanding in the first place. In this paper, we find that the scale factor can be interpreted as the gravitational potential of the entire Universe whose magnitude changes over a spherical timelike dimension rather than a spacelike dimension. The scale factor impacts both the space and time dimensions analogous to how the coefficients of the radial and time dimensions of the external Schwarzschild metric generate the local gravitational potential around a spherically symmetric body. This interpretation of the scale factor gives us an arrow of time that points forward in time during the expansion phase and backwards in time during the proceeding collapse phase and is generated by the masses of a Universe and anti-Universe moving in opposite directions of time. Details regarding the scale factor as a gravitational potential is given in section X.

It will be argued in this paper that the metric properly describing both the space and time curvature (and therefore the global gravitational potential) of the Universe is the *internal* Schwarzschild metric. This metric is a spherically symmetric vacuum solution. Consider that the external Schwarzschild metric, which is also a spherically symmetric vacuum solution, can be used to describe the worldlines of particles on an infinitely thin shell collapsing toward a center in space. For the internal metric, we can imagine that the matter and energy

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in the Universe is isotropically distributed throughout infinite space (3D space in this case), but exists only at the present time (time is the radius in this case) where the past and future are vacuums. If we accept this assumption and that the Universe is spherically symmetric, then according to Birkhoff's theorem, the internal metric is the *only* possible cosmological metric because the Schwarzschild solution is the only spherically symmetric vacuum solution in General Relativity. How the worldline of a particle can exist in both the internal and external metric is explained in section XI.

In section V we solve for the unknowns for the internal Schwarzschild metric, namely our current cosmological position in the metric and the counterpart of the Schwarzschild radius, using existing cosmological data. The model is then used to calculate relevant cosmological parameters and it is found that the model fits the cosmological data very well.

In section VII, the internal metric is interpreted as having imaginary (as in complex numbers) cosmological space and time dimensions where the entire Universe behaves like a spherically symmetric distribution of matter filling infinite space and falling through time. These imaginary dimensions exist alongside the real dimensions of the local metrics. The Universe and anti-Universe are falling through the imaginary time dimension described in that section. It is shown that the Universe and anti-Universe undergo an expansion phase followed by a collapse, where they annihilate with each other and pair production then gives birth to a new pair of Universes as the cycle repeats.

In section IX, we place the external metric in the background cosmology of the internal metric and show that a Black Hole event horizon can never form during the expansion phase and gravitational potentials reverse their directions during the collapse phase such that gravity becomes repulsive and would-be Black Holes become White Holes.

In section XV, it is postulated that Dark Matter is ordinary matter separated from us in a such a way that we are not connected with null geodesics. This is possible due to the form of the internal metric in how it treats space and time. It is a symmetry of space and time equivalent to why, in our present moment, we can only see a given galaxy as it was at a single time in the past as opposed to seeing many of its past states. We then discuss the transit of the singularity and address the fact that proper distances go to infinity there.

In the end we see that the use of the internal Schwarzschild metric as a model of Cosmology results in a total and perfect symmetry between space and time, the principle that lies at the core of relativity theory.

We will begin the argument by examining the Schwarzschild metric in detail.

## II. THE SCHWARZSCHILD METRIC

The Schwarzschild metric is the simplest non-trivial solution to Einstein's field equations. It is a vacuum solution for the spacetime around a spherically-symmetric distribution of energy. The the external and internal forms of metric can be expressed as (coordinates in the external metric are primed to distinguish them from the internal metric coordinates):

$$d\tau'^2 = \frac{r' - r_s}{r'} dt'^2 - \frac{r'}{r' - r_s} dr'^2 - r'^2 d\Omega'^2 \tag{1}$$

$$d\tau^2 = -\frac{u - r}{r} dt^2 + \frac{r}{u - r} dr^2 - r^2 d\Omega^2 \tag{2}$$

Equation 1 is the external metric with $t'$ being the timelike coordinate and $r'$ being the timelike coordinate. The Schwarzschild radius of the metric is given by $r_s = 2GM$ in natural units. We use the prime notation for the coordinates here to distinguish the external coordinates from the internal coordinate. The external metric is the metric for an eternally spherically-symmetric vacuum centered in space. This metric is also used to describe the vacuum outside a spherically symmetric object occupying a finite amount of space (like a star or planet). This metric as written in Equation 1 becomes the Minkowski metric as $r' \to \infty$.

Equation 2 is the internal metric with $t$ being the spacelike coordinate and $r$ being the timelike coordinate. This describes the metric for a spherically symmetric vacuum centered on a point in time. The constant $u$ is a time constant that will be later derived from cosmological data. Analogous to the external case, this metric should also describe a vacuum of time outside a spherically-symmetric object spanning infinite space. The center of the metric is everywhere in space, but at a single point in time (just like one could say that the vacuum described in the external case is centered at all times on a single point in space).

An important observation is that the internal metric describes a vacuum solution to the field equations. But the Universe is clearly filled with energy, so how can this solution be the Cosmological metric? In order to satisfy the requirements of the metric, the Universe must be "a spherically-symmetric energy distribution occupying an infinite amount of space for a finite amount of time". For this metric to be a cosmological description, it must be that Universe only truly exists in the present and in a very real sense moves into the future. The surrounding vacuum is the future, and the Universe is freefalling through time toward the temporal center of the metric.

Time being the radial dimension of the internal metric combined with the fact that the solution is a vacuum solution gives a mathematical justification for our intuitive notions of past, present, and future. The in-homogeneity along the radial direction gives us an arrow of time that distinguishes the 'past' and 'future' analogous to the way the external solution gives us an absolute distinction between 'up' and 'down'. And the vacuum as described above gives us a boundary between them, that boundary being the 'present' time, when the matter/energy of the Universe is actually positioned in the spacetime.

It should also be noted that our local motion through space $\frac{dr'}{d\tau'}$ is measured relative to some local object such as the earth or the sun whereas our motion through cosmological space $\frac{dt}{d\tau}$ is measured relative to the CMB from the temperature dipole. The same is true for orbital velocities. The local orbital velocity $r'\frac{d\Omega'}{d\tau'}$ is measured relative to the earth or sun for example, whereas orbital velocity in cosmological space $r\frac{d\Omega}{d\tau}$ is measured from the observed movement of the temperature dipole on the CMB and the object's radial distance in cosmological time $r$. This is discussed further in section XI.

Observation has shown that the Universe is:

- Spherically Symmetric
- Homogeneous in space
- In-homogeneous across time

We will also make one further assumption in this paper:

- The Universe only ever occupies a single instant of Cosmic time and moves from one moment of cosmic time to the next where the time measured by observers between cosmic times depends on their respective motions.

Relativity of simultaneity does not prohibit the idea of the energy existing at a specific Cosmological time because of the nature of the metric. In Cosmology, we can determine absolute motion and absolute simultaneity because we have the Cosmic Microwave Background. For example, consider two events that are causally disconnected. If observers at each event see the CMB temperature to be uniform in all directions (the observers are co-moving), then if both observers measure the CMB to have the same temperature at both events, then we know the events are absolutely simultaneous, even if a third observer in motion sees them as non-simultaneous. Any observer in motion through space, inertial or otherwise, will see a dipole on the CMB, and that dipole will provide all the info about the state of motion of the observer. Therefore, we can define past, present, future, and motion in an absolute sense. To put it another way, the fact that cosmological time is finite into both the past and future allows us to specify the distance of any event from either the beginning or end of time absolutely in terms of the CMB temperature, which relates directly to the cosmological coordinate time. Different observers will disagree on how much time has elapsed according to their local clocks due to the time dilation effects of their local gravitational fields and peculiar motions, but everything in the Universe is falling together in the time dimension

Let us call events the same distance away from us in time celestial spheres. We can classify these spheres into three types:

1. **Dynamic Spheres** – These are the spheres that galaxies reside on. Objects on these spheres maintain a constant coordinate distance from us and move forward in time. We are able to move toward or away from objects on these spheres by moving through space. If we fix our sights on a particular galaxy, the light we see from that galaxy is being emitted later in time as we ourselves move through time.

2. **Static Spheres** – These are spheres fixed in time. The Cosmic Microwave Background is the most obvious example of these spheres. Light from the CMB sphere is always emitted from the same cosmological time, but as we ourselves move through time, we see light from that time emitted from farther and farther away from us in space, giving the impression that the CMB sphere is growing. We cannot move toward or away from any objects on this sphere because it is frozen in time.

3. **The Dark Sphere** – The Dark Sphere is the Big Bang and lies beyond the CMB. It is in principle unobservable for two reasons. First, the CMB is opaque so that any light from the Big Bang cannot penetrate it. Second, even if the CMB was not blocking our view, any light from that sphere would be infinitely redshifted in the frame of all future observers since the scale factor on that sphere is zero.

These spheres are shown in terms of the internal Schwarzschild metric in Figure 1. Figure 1 shows the Schwarzschild coordinates of the internal metric plotted on the Kruskal-Szekeres coordinate plane [1]. In these coordinates, space is the '$t$' coordinate emanating from the center of the diagram (Big Bang) and time is the '$r$' coordinate depicted as hyperbolas (time is flowing forward as $r$ goes toward zero). The upper right quadrant of this diagram represents a single fixed direction ($\theta = const$, $\phi = const$). So each bold line representing a sphere would be a point on each sphere over time. Note that light on this diagram travels on 45-degree lines.

[1] Figures 1, 6, 8, 9, and 10 are modifications of: 'Kruskal diagram of Schwarzschild chart' by Dr Greg. Licensed under CC BY-SA 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Kruskal_diagram_of_Schwarzschild_chart.svg#/media/File:Kruskal_diagram_of_Schwarzschild_chart.svg

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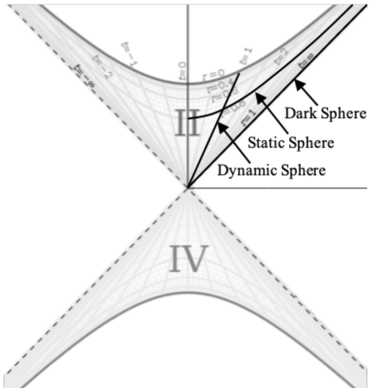


FIG. 1. Celestial Sphere Types on Kruskal-Szekeres Coordinate Chart

It is also notable from the metric that even though $r$ is a timelike coordinate in this case, the $rd\Omega$ term is still spacelike, so objects on the celestial spheres at constant $r$ are spacelike separated, which is what we expect.

## III. THE SCALE FACTOR

Expressions for the proper time interval along lines of constant $t$ and $\Omega$ and the proper distance interval along hyperbolas of constant $r$ and $\Omega$ from Equation 2 are:

$$\frac{ds}{dt} = \pm\sqrt{\frac{u-r}{r}} = \pm a \tag{3}$$

$$\frac{d\tau}{dr} = \pm\sqrt{\frac{r}{u-r}} = \pm\frac{1}{a} \tag{4}$$

And the coordinate speed of light is given by:

$$\left(\frac{dt}{dr}\right)_{light} = \pm\frac{r}{u-r} = \pm\frac{1}{a^2} \tag{5}$$

Where $a$ is the scale factor. First we should notice that none of the three equations depend on the $t$ coordinate. This is good because the $t$ coordinate marks the position of other galaxies relative to ours. Since all galaxies are freefalling in time inertially, the particular position of any one galaxy should not matter. The proper temporal velocity, proper distance, and coordinate speed of light only depend on the cosmological time $r$.

A plot of the scale factor vs. $r$ (with $u = 1$) is given in Figure 2 below:

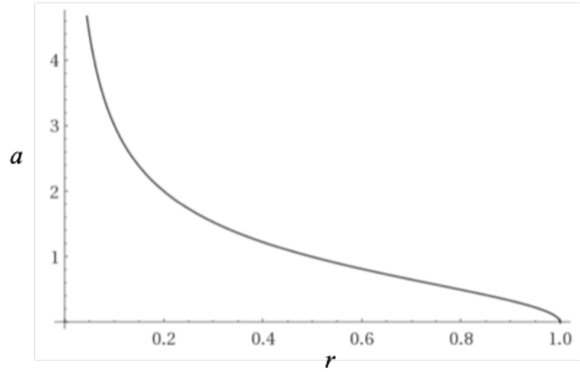


FIG. 2. Scale Factor vs. $r$ for $u = 1$

## IV. THE CO-MOVING OBSERVER

Let us take a co-moving observer somewhere in the Universe we label as $t = 0$ as the origin of an inertial reference frame. We can draw a line through the center of the reference frame that extends infinitely in both directions radially outward. This line will correspond to fixed angular coordinates ($\theta$,$\phi$). There are infinitely many such lines, but since we have an isotropic, spherically symmetric Universe, we only need to analyze this model along one of these lines, and the result will be the same for any line.

The radial distance in this frame is kind of a compound dimension. It is a distance in space as well as a distance in time. The farther away a galaxy is from us, the farther back in time the light we currently receive from it was emitted. Fortunately the internal spacetime of the Schwarzschild solution (Equation 2) plotted in Kruskal-Szekeres coordinates provides us with a method to understand this radial direction. Figure 1 showed the internal solution on a Kruskal-Szekeres coordinate chart where, in this model, the hyperbolas of constant $r$ represent spacelike slices of constant cosmological time and the rays of $t$ represent spatial distances.

We must determine the paths of co-moving observers ($dt = d\Omega = 0$) in the spacetime. For this we need the geodesic equations for the internal Schwarzschild metric [1] given in Equation 2. In these equations $u$ represents a time constant (in Figure 1, the value of $u$ is 1). The following equations are the geodesic equations of the internal metric for $t$ and $r$ ($0 \le r \le u$) for $d\Omega = 0$:

$$\frac{d^2t}{d\tau^2} = \frac{u}{r(u-r)}\frac{dr}{d\tau}\frac{dt}{d\tau} \tag{6}$$

$$\frac{d^2r}{d\tau^2} = \frac{u}{2r^2} \tag{7}$$

Looking at points $0 < r < u$, then by inspection of Equation 6 it is clear that an inertial observer at rest at $t$ will remain at rest at $t$ ($\frac{d^2t}{d\tau^2} = 0$ if $\frac{dt}{d\tau} = 0$).

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Let us next demonstrate how the internal metric fits with existing cosmological data and calculate various cosmological parameters using that data.

## V. CALCULATION OF COSMOLOGICAL PARAMETERS

In order to compare this model to cosmological data, we must solve for $u$ and find our current position in time ($r_0$) in the model. Reference [2] gives us transition redshift values ranging from $z_t = 0.337$ to $z_t = 0.89$, depending on the model used. We can use the expression for the scale factor in Equation 3 to get the expression for cosmological redshift from some emitter at $r$ measured by an observer at $r_0$ [1]:

$$1 + z = \frac{a_0}{a} = \sqrt{\frac{r(u - r_0)}{r_0(u - r)}} \tag{8}$$

Furthermore, the deceleration parameter is given by:

$$q = \frac{\ddot{a}a}{\dot{a}^2} = \frac{4r}{u} - 3 \tag{9}$$

By setting Equation 9 equal to zero, we find that the scale factor at the transition from decelerating to accelerating expansion $a_t$ is:

$$a_t = \sqrt{\frac{4}{3} - 1} = \frac{1}{\sqrt{3}} \tag{10}$$

Using Equations 8, 10, and the transition redshift estimate, we can get an expression for the present scale factor:

$$a_0 = a_t(1 + z_t) = \frac{1 + z_t}{\sqrt{3}} \tag{11}$$

Next, we find expressions for $u$ and our current radius $r_0$ by noting that the Universe has been found to be roughly 13.8 billion years old. Therefore, we can set $\alpha_{r_0} \equiv u - r_0 = 13.8$ and use Equations 3 and 11 to obtain the following for $u$ and $r_0$:

$$r_0 = \frac{u - r_0}{a_0^2} = \frac{\alpha_{r_0}}{a_0^2} = \frac{3\alpha_{r_0}}{(1 + z_t)^2} \tag{12}$$

$$u = r_0 + \alpha_{r_0} = \alpha_{r_0}\left(\frac{3}{(1 + z_t)^2} + 1\right) \tag{13}$$

Next we compute the CMB scale factor ($a_{CMB}$) and coordinate time ($r_{CMB}$) in this model where the redshift of the CMB ($z_{CMB}$) is currently measured to be 1100:

$$a_{CMB} = \frac{a_0}{1 + z_{CMB}} \tag{14}$$

$$r_{CMB} = \frac{u}{1 + a_{CMB}^2} \tag{15}$$

We can next derive the Hubble parameter equation using the scale factor. The Hubble parameter is given by (in units of $(Gy)^{-1}$):

$$H = \frac{\dot{a}}{a} = \frac{u}{2r(u - r)} \tag{16}$$

Table I below gives the values of $u$, $r_0$, $H_0$, $a_0$, $q_0$, $a_{CMB}$, $r_{CMB}$, and $q_{CMB}$ given the upper and lower bounds of $z_t$ from [2] as well as the average of the upper and lower bound values and assuming $\alpha_{r_0} = 13.8$. All times are in $Gy$ and $H_0$ is in $(km/s)/Mpc$.

| $z_t$ | $\alpha_{r_0}$ | $u$ | $r_0$ | $H_0$ | $a_0$ | $q_0$ | $a_{CMB}$ | $r_{CMB}$ | $q_{CMB}$ |
|---|---|---|---|---|---|---|---|---|---|
| 0.337 | 13.8 | 37.0 | 23.2 | 56.6 | 0.77 | -0.49 | 0.0007 | 36.95 | 0.99 |
| 0.614 | 13.8 | 29.7 | 15.9 | 66.2 | 0.93 | -0.86 | 0.0008 | 29.65 | 0.99 |
| 0.89 | 13.8 | 25.4 | 11.6 | 77.6 | 1.09 | -1.17 | 0.0010 | 25.35 | 0.99 |

TABLE I. Limiting Cosmological Parameter Values Based on $z_t$ Measurement and a 13.8 Gy Age of the Universe

From the results in Table I, we see that the true transition redshift is likely between 0.614 and 0.89 given the fact that the current value of the Hubble constant is known to be in that range. Thus, more accurate measurements of the transition redshift are needed to increase the confidence of this model, though we do see that it is able to reproduce measured results.

Table II has the proper times from $r = u$ to the current time as well as the CMB for stationary, inertial observers ($dt = rd\Omega = 0$) by integrating Equation 2. The column $\tau_{tot}$ gives the time from $r = u$ to $r = 0$. The expression for $\tau_{tot}$ turns out to be quite simple:

$$\tau_{tot} = \frac{\pi}{2}u \tag{17}$$

In Table II below, the column $\tau_{remain}$ gives the time between $r = r_0$ and $r = 0$.

| $z_t$ | $\alpha_{r_0}$ | $\tau_0$ | $\tau_{tot}$ | $\tau_{remain}$ | $\tau_{CMB}$ |
|---|---|---|---|---|---|
| 0.337 | 13.8 | 42.2 | 58.1 | 15.9 | 8.6 |
| 0.614 | 13.8 | 37.1 | 46.7 | 9.6 | 2.4 |
| 0.89 | 13.8 | 33.7 | 39.9 | 6.2 | 2.3 |

TABLE II. Limiting Proper Times Based on $z_t$ Measurements and an age of 13.8 Gy for the Universe (Time is in Gy)

Note that while the coordinate times for the current age of the Universe ($u - r_0$) are close to current estimates (for high $z_t$), the proper time $\tau_0$ is actually much larger. And even though we are presently only about halfway through the "coordinate life" of the Universe (according to Table I), the amount of proper time remaining is actually much less than the amount of proper time that has already passed (according to Table II). This provides a measurable prediction from the model: as telescopes such as the JWST peer farther into the past with greater accuracy, we should expect to find stars, galaxies, and structures that are much older than expected because of

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the increased amount of proper time available for such things to form in the early Universe. Hints of this has already been found with the star HD 140283, whose age is estimated to be nearly the age of the Universe itself [3].

Next we would like to use the $u$ and $r_0$ values found to create an envelope on a Hubble diagram to compare to measured supernova and quasar data. First we need to find $r$ as a function of redshift. We can do this by solving for $r$ in Equation 8:

$$r = \frac{u(1+z)^2}{a_0^2 + (1+z)^2} \tag{18}$$

We can derive the expression for $t$ vs. $r$ along a null geodesic where the geodesic ends at the current time $r_0$ and $t = 0$ by setting $d\tau = rd\Omega = 0$ in Equation 2 and integrating:

$$t = \int_{r_0}^{r} \frac{r}{u-r} dr = u \ln\left(\frac{u-r_0}{u-r}\right) + r_0 - r \tag{19}$$

Next we substitute Equation 18 into Equation 19 to get coordinate distance in terms of redshift:

$$t = r_0 + u\left[\ln\left(\frac{a_0^2 + (1+z)^2}{1+a_0^2}\right) - \frac{(1+z)^2}{a_0^2+(1+z)^2}\right] \tag{20}$$

We need to convert the distance from Equation 20 to the distance modulus, $\mu$, which is defined as:

$$\mu = 5\log_{10}\left(\frac{D_L}{10}\right) \tag{21}$$

Where $D_L$ in Equation 21 is the luminosity distance. Luminosity distance is inversely proportional to brightness $B$ via the relationship:

$$B \propto \frac{1}{D_L^2} \tag{22}$$

The brightness is affected by two things. First, the spatial expansion will effectively increase the distance between two objects at fixed co-moving distance from each other. This will reduce the brightness by a factor of $(1+z)^2$ (because the distance in Equation 22 is squared). But there is also a brightening effect caused by the acceleration in the time dimension. We define $\nu \equiv \frac{d\tau}{dr} = \frac{1}{a}$ as the temporal velocity of the inertial observer at some $r$ and the speed of light at that $r$ as $\nu_c \equiv \frac{dt}{dr} = \frac{1}{a^2}$. The ratio of these velocities gives us:

$$\frac{\nu_c}{\nu} = \frac{dt}{dr}\frac{dr}{d\tau} = \frac{dt}{d\tau} = \frac{a}{a^2} = \frac{1}{a} \tag{23}$$

Equation 23 tells us how far a photon travels over a given period of time measured by the inertial observer's clock. So we see that as light travels from the emitter to the receiver, this speed decreases. This decrease in the speed from emitter to receiver will result in an increased photon density at the receiver relative to the emitter, increasing the brightness. Therefore, this effect will increase the brightness by a factor of:

$$\frac{a_0}{a} = 1 + z \tag{24}$$

This effect is not accounted for in the current relativistic cosmological models and therefore gives a second prediction that light from the distant Universe should appear brighter than expected.

Taking these brightness effects into account, the total brightness will be reduced by an overall factor of $1 + z$ relative to the case of an emitter and receiver at rest relative to each other in flat spacetime. Equation 22 in terms of co-moving distance $t$ and redshift $z$ becomes:

$$B \propto \frac{1+z}{(t(1+z))^2} \rightarrow B \propto \frac{1}{t^2(1+z)} \tag{25}$$

Giving the luminosity distance as a function of co-moving distance $t$ and redshift $z$:

$$D_L = t\sqrt{1+z} \tag{26}$$

Which gives us the final expression for the distance modulus as a function of co-moving distance and redshift:

$$\mu = 5\log_{10}\left(\frac{t\sqrt{1+z}}{10}\right) \tag{27}$$

A plot of distance modulus vs. redshift is shown in Figure 3 below plotted over data obtained from the Supernova Cosmology Project [4]. Curves calculated from all three values of $z_t$ in Table I are plotted, giving an envelope for the model's prediction of the true Hubble diagram.

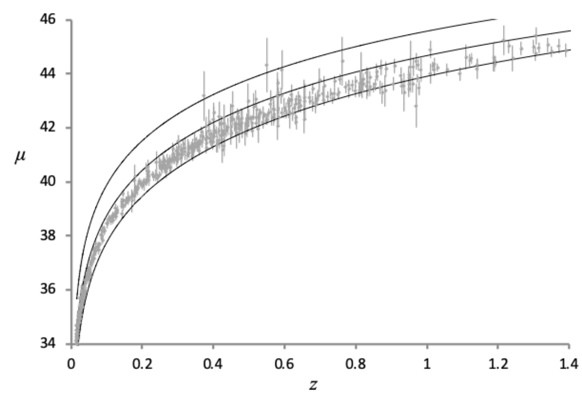


FIG. 3. Distance Modulus vs. Redshift Plotted with Supernova Measurements

Note that the middle curve corresponds to $z_t = 0.614$ and the lower curve corresponds to $z_t = 0.89$. The supernova data is better fit by a curve between these values. The curve halfway between (with $z_t = 0.75$) gives us $H_0 = 71.6$, $a_0 = 1.0$, $q_0 = -1.0$, $u = 27.3$, and $r_0 = 13.5$.

In [5], the authors analyze a large sample of quasar data to obtain distance moduli at higher redshifts than

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is possible with supernova data. Figure 4 shows the same predicted envelope from Figure 3 for the Hubble diagram plotted out to higher redshifts with the quasar data from [5] also shown with error bars. The black diamonds in the figure are the 18 high-luminosity XMM-Newton quasar points described in [5].

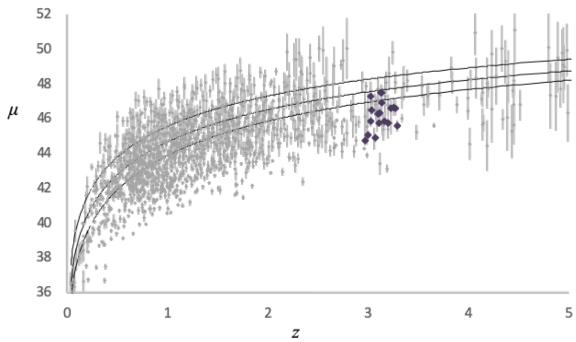


FIG. 4. Distance Modulus vs. Redshift Plotted with Quasar Measurements

Finally, by subtracting $r_0$ from Equation 18 we can calculate the lookback time for a given redshift. Figure 5 shows the lookback time vs. redshift for the three transition redshifts.

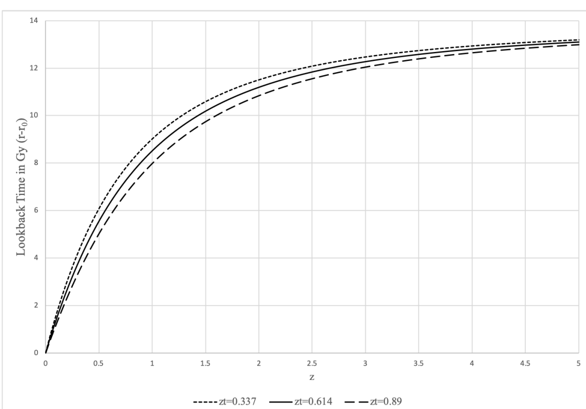


FIG. 5. Lookback Time vs. Redshift

## VI. THE ANTI-UNIVERSE

Figure 6 shows the full Schwarzschild metric in Kruskal-Szekeres coordinates. The diagram can be split in two along the diagonal where in the top right half, forward time points up in both the internal and external regions while in the bottom right half, forward in time points down. The direction of positive space is also swapped when looking at the upper and lower halves. For the external metric, the radius increases to the right in the upper half and to the left in the lower half. For the internal metric, the spatial $t$ coordinate goes from $-\infty$ to $+\infty$ from left to right in the upper half and from right to left in the lower half.

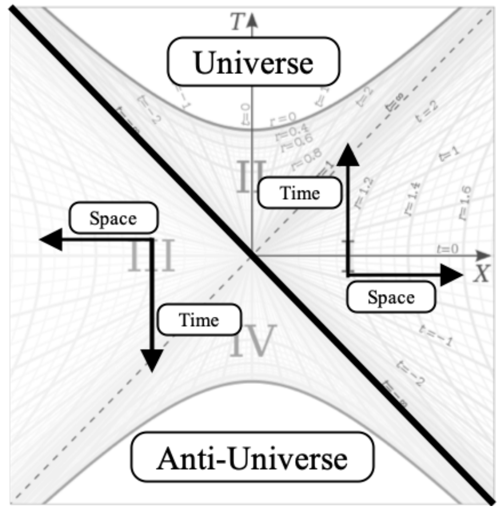


FIG. 6. Universe and Anti-Universe

We can therefore conjecture that the diagram is describing both a Universe expanding up from the center and an anti-Universe expanding down from the center, each one moving toward a singularity. We expect that the anti-Universe is made of mostly anti-matter because the directions of both time and space are reversed relative to each other and therefore we expect the particles of the second Universe to have opposite charges relative to the first (more on this in Section XVII). This interpretation provides a resolution to the question of why we only tend to see matter in our Universe. It is because the equivalent amount of antimatter is moving away from us as a mirror Universe in the opposite direction of time. Thus, the pair of Universes (or 'Duoverse') satisfies CPT symmetry and the Kruskal coordinates $T$ and $X$ in Figure 6 represent cardinal directions of space and time.

## VII. COMPLEX SPACETIME

Notice that the $dr$ and $rd\Omega$ terms in Equation 2 have opposite signs. As is the case in Equation 1, we would expect the angular and pure radius terms to have the same sign. We can remedy this by changing Equation 2 to:

$$d\tau^2 = \frac{u-r}{r} d\left(it'\right)^2 - \frac{r}{u-r} d\left(ir'\right)^2 - r^2 d\Omega^2 \qquad (28)$$

Equation 28 implies that the imaginary counterpart of the time coordinate is spacelike and the imaginary counterpart of the spatial (radius) coordinate is timelike. We can even see how the timelike $r$ coordinate and spacelike $t$ coordinate retain some of the time and spacelike characteristics of their real counterparts.

To see how the imaginary $t'$ coordinate, which is spacelike in the internal metric retains some timelike properties, we need to observe a surface of constant $r$ with changing $t$. The Cosmic Microwave Background is such

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a surface. If one were to observe a patch of the CMB over billions of years, one would see it change over time with a given patch in the sky having slight changes in temperature distribution over time. But the surface is not actually changing over time because it is by definition a surface at a fixed time. The changes we would observe would come from the fact that we are seeing the CMB in the direction we are observing it at greater distances from us over time, as if the surface we see is moving through the Universe itself at that fixed time. So even though the CMB would appear to change over time, it isn't actually changing with time, we are only seeing it at greater coordinate distances as we move through time.

Even more obvious is how the imaginary $r$ coordinate, which is timelike, still retains spacelike characteristics. When we look out at the Universe, it almost seems like we are looking at galaxies surrounding us in space in the present time. But it is more useful to measure those distances in time because the Universe is homogeneous in space at a given time, so specifying the distance in spatial coordinates is less useful because the differences we see in the structure of the Universe at different distances are due to their separation from us in time, not space. Therefore, it feels like the farther away we look in space the more different the Universe looks, it is not the distance in space that is responsible for the differences but rather the distance in time.

It is notable that the $d\Omega$ term is unchanged in the internal metric relative to the external metric where surfaces of constant $r$ are spacelike in both cases. This makes sense because surfaces of constant $r$ in spherically symmetric Universes are at a constant distance in both space and time in all cases and so the angular dimension of the metric has no imaginary counterpart.

So if we put the observer at the center of a spherically symmetric space, we can say that every direction has both real and imaginary space and time dimensions associated with it. If we again consider the CMB in a particular direction, no matter how long we travel in that direction, we will not reach the CMB because it is separated from us in the imaginary spatial dimension, which is related to the timelike radius of the internal metric. The imaginary cosmological metric, whose main attribute is the scale factor of the Universe, determines the scaling of the real metrics of the Universe throughout cosmological time.

Looking at Figure 6, let us imagine a complex plane perpendicular to the page whose real axis is coincident with the $T$ axis of Figure 6. Setting $u = 1$, in Kruskal coordinates the relationship between $T$ and $r$ along $t = 0$ is:

$$T = \pm\sqrt{(1-r)e^r} \tag{29}$$

$$r = 1 + W_0\left(-\frac{T^2}{e}\right) \tag{30}$$

Where $W_0$ is the Lambert W function. Therefore, we can plot the relationship between $T$ and $ir$ on the aforementioned complex plane in Figure 7 for both the matter and antimatter Universes:

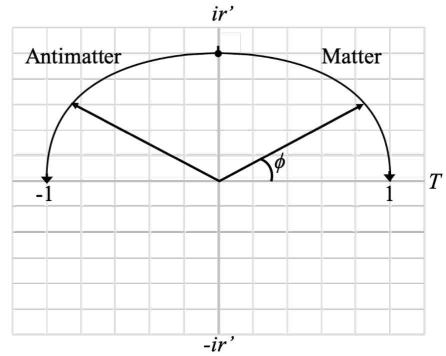


FIG. 7. Imaginary Radius to Real Radius for the Matter (Right) and Antimatter (Left) Universes

In Figure 7, we see two oblong curves, the right one for the matter Universe and the left one for the antimatter Universe with a vector whose projections give the magnitudes of the real and imaginary radii at a given time. The two Universes are coincident at $i$, representing the event horizon/Big Bang era (in the rest of this paper, the Big Bang will be referred to as Annihilation). Here, we can say the matter and antimatter Universes have annihilated with each other and new pairs of matter and antimatter are created from the annihilation, creating the two Universes travelling in opposite directions of time. Over time, the imaginary radii of the Universes decrease while the real radii increase up to the singularity, where the imaginary radii are zero and the real radii are 1.

The antimatter Universe moves in the opposite direction of time relative to the matter Universe, and so we expect their vectors on this plane to rotate in opposite directions as shown.

Looking at Figure 7, we can mirror the curves in the real axis to account for the $-ir'$ space. Doing so would indicate that right as the Universes reach maximum expansion, the geodesics reverse in time and the Universes begin to re-collapse toward each other.

We can think of the Universe as the imaginary counterpart of a galaxy. Let's imagine starting form the center of a galaxy and moving out through space at the center. At the center of the galaxy, we have a spherically symmetric event horizon. The 'Dark Sphere' of Figure 1 is the imaginary counterpart of the galaxy's event horizon. As we move out radially, we first have a dense accretion disk around the horizon. The CMB is the imaginary counterpart of this disk. As we move out farther and farther radially, the galaxy becomes less and less dense. The scale factor of the Universe is the imaginary counterpart of this reduction in density at greater radii of the galaxy. Eventually we get to a maximum radius of the galaxy with minimum density. The singularity is the imaginary counterpart of the galaxy's edge. It has been observed that the size of a galaxy's black hole is related to the

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overall size of the galaxy itself. This is analogous to the fact the the radius of the internal solution determines the timescale of the expansion phase of the Universe and the maximum size of the observable Universe. Finally, the many galaxies in our Universe are analogous to the repeated expansion and collapse cycles of the Universe where each of the galaxies is an independent cycle of the Universe. We will discuss observable Universes and the repeating cycles in later sections.

## VIII. NEWTONIAN ANALOG

This entire system is the temporal equivalent of two masses initially moving apart from one another until they reach a maximum separation distance $u$. At that point they will start falling toward each other again due to mutual gravitational attraction. When they meet at their common center, they annihilate, creating new pairs of matter/antimatter particles and begin moving away from each other again, as if they've bounced off each other. It is equivalent to the exchange of potential and kinetic Energy, but in the time dimension.

Now consider the Newtonian example of a ball in a gravitational field rising to a maximum height $h$ and then falling back to the ground. $\frac{dh}{dt}$ will be positive on the way up, negative on the way down and zero at max height. But this also means that $\frac{dt}{dh}$ will be infinite at the maximum height because $dh = 0$ there. We might think that when comparing this to the present case, $t \to \tau$ and $h \to r$, but this is incorrect. We know that $r$ is our time coordinate and $\tau$ is the distance along the geodesic, so $h \to \tau$ and $t \to r$. So from Equation 4, we see that, just like in the Newtonian example, $\frac{d\tau}{dr} = 0$ and $\frac{dr}{d\tau} = \infty$ at the singularity because in this case $d\tau = 0$ at the turnaround.

## IX. CONDENSATION AND EVAPORATION

We will now describe in detail the physical meaning behind the 'Expansion' and 'Collapse' phases of the Universe. Looking at Equation 6, we see that the $\frac{u}{r(u-r)}$ term is always positive. During the expansion phase, $\frac{dr}{d\tau}$ is negative and therefore $\frac{d^2t}{d\tau}$ will always be in the opposite direction of $\frac{dt}{d\tau}$. Therefore, this tells thus that the peculiar velocities of cosmological objects will be reduced over time when no forces act upon them. Equation 6 describes an inertial force acting on all objects, slowing them down during the expansion phase. If the Universe is far from $r = u$ and $r = 0$, it only has noticeable effects at very large time scales and velocities (because $\frac{u}{r(u-r)} = 2H$ is very small for human velocity and time scales. For instance, currently $H \approx 71.6\ km/s/Mpc$ so converting that to $1/s$ gives a value on the order of $\sim 10^{-18}$). During collapse, $\frac{dr}{d\tau}$ is positive and now the acceleration acts in the direction of motion of the object and therefore increases its velocity over time in that phase.

So we can view the expansion phase as a condensation of the Universe. The Universe starts out as a hot plasma after the annihilation event, after which it cools and motion of the particles slow down. At the beginning of expansion, the deceleration is large (infinite at $r = u$ allowing null geodesics to become timelike), then for a long period the deceleration is small, and on approach to the signularity it once again goes to infinity. For just a moment at the singularity, all motion stops completely. The particles stop completely at the singularity because $\frac{u}{r(u-r)}$, $\frac{dr}{d\tau}$ and therefore $\frac{d^2t}{d\tau}$ become infinite there putting an infinite inertial drag force on all objects. This is true even for objects with a proper acceleration. So the expansion counter-intuitively effectively stabilizes gravitational structures more and more as time moves forward, promoting this condensation.

Likewise, the collapse phase can be viewed as an evaporation. After condensation, the Universe begins the collapse phase. As the Universe emerges from the singularity, the inertial force that now tends to accelerate is extremely large (falling from infinity at the singularity), but the $\frac{dt}{d\tau}$ of everything is zero, so there is no initial acceleration at the very beginning of collapse. But any perturbation to a particle's state of rest will induce an inertial acceleration in the direction of motion. Therefore, particles will naturally gain momentum over time and the Universe will heat up as gravitationally bound structures begin to break down and the Universe tends back toward a state of hot plasma as it approaches the annihilation event. Once again $\frac{u}{r(u-r)}$, $\frac{dr}{d\tau}$ and therefore $\frac{d^2t}{d\tau}$ become infinite at the annihilation event, sending all particles toward light-like geodesics as though they effectively lose all their mass.

Now let us consider this from the perspective of the external metric. Consider a star that has collapsed to form a Black Hole. As will be demonstrated, the star can never actually form an event horizon, but we can imagine that the star is massive enough that it becomes a 'Dark Star'.

The Schwarzschild metric depicted in Figure 6 describes and 'eternal' Dark Star. But we could also say that it describes a Dark Star from the beginning of the Universe to the end of the Universe, with the beginning of the Universe being marked by the $t' = -\infty$ line and the end being the $t' = \infty$ line. The Schwarzschild metric is asymptotically Minkowskian, so it does not truly represent the spacetime around a real spherically symmetric mass since the background Universe has been observed to be non-Minkowskian, but we can use this metric along with what has been determined from Equation 6 to approximate the expected trajectory for a freefalling object in the field of a Dark Star over the expansion and collapse phases of the Universe. The path $\frac{dr'}{dt'}$ of an object in freefall in the field of a Dark Star as seen by a distant

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is given by [6]:

$$\frac{dr'}{dt'} = \pm\left(\frac{r'-r_s}{r'}\right)\sqrt{\frac{r'_0(r'_o - r')}{r'(r'_0 - r_s)}} \tag{31}$$

Where $r'_0$ is the radius at which the object begins falling from rest and $r_s$ is the Schwarzschild radius. The focus here is not on the equation itself, which is a well-known solution, but at the $\pm$ in front of it that comes from taking the square root. Typically, when doing this calculation, we would take the negative sign and start falling from $t = 0$ just because we expect that gravity is always attractive and taking the negative sign ensures that $dr'$ is negative while $dt'$ increases from zero to infinity. But given the fact that we now know that our proper motion through time $\frac{dr}{d\tau}$ (where $r = ir'$) is negative during expansion and positive during collapse, this suggests that we should take the negative root when the Universe is expanding and the positive root during collapse. The logic is straightforward: We assert that the time at which the Universe changes from expansion to collapse is at $t' = 0$ and therefore the expansion occurs in the $t' < 0$ region and collapse occurs in the $t' > 0$ region. For a worldline going from $t' = -\infty$ to $t' = \infty$, $dt'$ will always be positive and $d\tau$ for the particle is always positive along the line. Therefore, we take the negative root in the $t' < 0$ region to account for $\frac{dr}{d\tau} < 0$ during expansion and the positive root in the $t' > 0$ region to account for $\frac{dr}{d\tau} > 0$ during collapse.

So during collapse, freefalling objects are ejected symmetrically out of the gravitational field of the object relative to expansion. Referring back to Equation 6, we see that motion through space becomes more and more limited as we approach the singularity. So when taking into account this cosmological drag, we can say that as a real object approaches $t' = 0$ in such a field, its worldline must become tangent to the $r'$ hyperbola closest to it. And as collapse begins, it will smoothly and symmetrically curve in the opposite direction.

Furthermore it should be noted that since the expansion phase takes place in the $t' < 0$ region, an event horizon can never form because that would require faster than light motion to achieve.

An approximate example of a real geodesic for an object in freefall in such a gravitational field is shown by the dark black line in Figure 8 through both the expansion and collapse phases of the Universe.

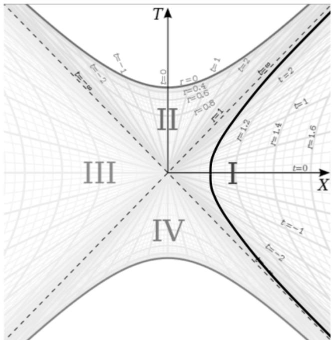


FIG. 8. Schwarzschild Freefall in Expanding and Collapsing Spacetime

The conclusion we can draw from this is as follows. During expansion, the background of the Universe glows with decreasing temperature and brightness over time via the CMB as gravitational structures stabilize and galaxies form. During this phase, some stars will collapse to form Dark Stars that we presently think of as Black Holes. By the time we reach the singularity, the Universe will be fully condensed and inert. At the singularity, light from the CMB will be infinitely redshifted such that it is no longer detectable and the background Universe becomes black (because $a_0$ in Equation 8 becomes infinite there). The observer will see a completely dark Universe at the singularity and over time, the Dark Stars will begin to glow like candles lighting up the darkness as the geodesics of the particles that were falling toward their centers during expansion reverse and now move outward. Shadow becomes flame. These former "Black Holes" effectively become "White Holes", with matter radiating from them, seemingly out of the vacuum, even though the radiation is coming from matter that had accumulated in that region during expansion. As the collapse proceeds, these White Holes will grow brighter and shrink as the matter and energy making them up escapes to the external Universe at higher and higher energies due to the increasing inertial acceleration from Equation 6. The Universe effectively evaporates as all gravitational structures break down. By the end of collapse, the Universe has returned to a state of increasingly dense plasma until it collides with the anti-Universe at the annihilation horizon.

## X. GLOBAL GRAVITATIONAL POTENTIAL

At this point, we see that the scale factor $a$ is not really a time-dependant scaling of the spatial metric, as it is treated in $\Lambda$CDM Cosmology. Rather, it should be seen as a global gravitational potential. It is the imaginary counterpart of the Schwarzschild gravitational potential. Whereas the Schwarzschild potential is constant in time and varies radially from a point in space, this global potential is constant across space and varies radially from a point in time. Recall that this discussion began with

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the argument that the entire, spherically symmetric Universe was falling through the cosmological time dimension $r$. The scale factor is the potential driving that motion through time.

Space is not expanding the way we currently think about it in terms of a stretching of space. What is changing is how quickly different points in space are able to communicate with each other. The image of space itself compressing to a point or ripping itself apart is misleading. At the beginning of expansion, we have a normal 3D space of particles that can communicate instantly with all other particles regardless of distance. This communication speed drops as expansion proceeds and local gravitational structures are able to form. As will be shown in section XV, when reaching the singularity where the scale factor is infinite, space is not ripped apart but rather the light cone angles have closed completely such that adjacent regions of space are unable to communicate with each other which manifests as infinite proper distances.

The scale factor being a gravitational potential is why the FRW metric fails to account for the accelerated expansion of the Universe without needing to invoke the ethereal Cosmological Constant. The Friedman equations in the absence of the Cosmological Constant can in fact be derived from Newtonian mechanics. Thus, the Friedman model is to cosmology as Newtonian gravity is to the external Schwarzschild solution. Whereas Newtonian gravity completely ignores the warping of space around a gravitating object, the FRW model completely ignores the warping of time around the present Universe. When Newtonian gravity failed to predict the precession in Mercury's orbit, it was initially presumed that an unknown planet must exerting a force on Mercury. The solution turned out to be a correction to the gravitational potential of the sun via the advent of General Relativity and the external Schwarzschild metric. Likewise, the acceleration of the expansion of the Universe is currently being attributed to the existence of some vague notion of 'Dark Energy', thought to be the energy of empty space. This problem is similarly resolved in this paper using General Relativity and its internal Schwarzschild metric to correct the gravitational potential of the Universe as a whole.

The temporal direction in which we move in this potential then determines whether the local potentials point inward toward massive objects or outward from them. So during expansion, the local gravitational potential gradient around a body points inward toward the body. During collapse, the gradient flips direction, pointing away from the body. Thus we see yet another symmetry emerge: while gravity is attractive during the expansion phase, it is repulsive during collapse, which is what we expect from a time-reversed Universe.

## XI. UNDERSTANDING COSMOLOGICAL MOTION: A THOUGHT EXPERIMENT

The conventional use of the Schwarzschild metric is of a single spacetime with admittedly odd properties that produce Black Hole horizons that swallow up information, but that interpretation at least uses a single set of coordinates and a single worldline for the particle. In this paper, it is argued that these metrics are related, but their coordinates do not quite describe the same things and, as will be shown in section XIII, they have different worldlines describing the same particle. This demands an explanation and we can understand the relationship better with a thought experiment.

Imagine a Universe full of Dark Stars, each one with a particle moving in the star's gravitational potential in arbitrary ways. We will focus in on one such system. Let's surround our Dark Star and particle system with a larger sphere containing both of them (call it a Cosmosphere) centered on the Dark Star and large enough that the path of the particle always remains inside it. The orientation of the system is locked to the Cosmosphere so that if the Cosmosphere moves or rotates, the system as a whole moves and rotates with it.

We already know that Equation 1 describes the path of the particle relative to the Dark Star and the $r'$ and $\Omega'$ coordinates are measured relative to the Dark Star. But the time coordinates of Equations 1 and 2 must be related because in section IX, we tied $t' = 0$ to the singularity, which is the cosmological time. So we therefore need first to define the cosmological time.

The CMB shines on the Cosmosphere, and the temperature monopole of that light is directly related to the cosmological time $r$ and therefore local time $t'$. When the temperature monopole is zero, we are at $r = t' = 0$. So the monopole temperature tells us the time and the sign of its gradient tells us whether the Universe is in the expansion or contraction phase.

This leaves us with cosmological linear and angular motion $\frac{dt}{d\tau}$ and $\frac{d\Omega}{d\tau}$. We can figure out our cosmological velocity $\frac{dt}{d\tau}$ by observing the magnitude and orientation of the temperature dipole cast on the Cosmosphere from the CMB. If the system is moving through $t$, one side of the sphere will be more blue than the monopole and the polar opposite side will be more red than the monopole. The Dark Star, which is at rest relative to the Cosmosphere can figure out how fast and in which cosmological direction the Cosmosphere is moving in by observing the magnitude of the dipole as well as the relative orientation of it. If the Dark Star sees the dipole move around on the Cosmosphere, then it knows that the Cosmosphere is changing its cosmological direction and therefore has a cosmological angular velocity $\frac{d\Omega}{d\tau}$ proportional to the rate at which the dipole moves across the sphere.

For pure angular motion with no change in $t$, there would only be a temperature monopole on the Cosmosphere, no dipole. The angular motion would be deduced by looking at the patterns of the hot and cold

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spot fluctuations in the monopole. These patterns would be observed to rotate over the Cosmosphere during pure angular motion. To the Dark Star, it would appear as though the Cosmosphere is rotating about the Dark Star. We discuss this in more detail in section XV.

If the Cosmosphere is co-moving, then the Dark Star will not see any temperature dipole, only a monopole. And if the Cosmosphere is co-moving and spinning, then the Dark Star will see a quadrupole where the poles of the axis of rotation are at the monopole temperature and the Cosmosphere gets more red as you look towards the equator. The spin axis and magnitude can therefore be deduced from that quadrupole's orientation and redness.

So we see that the spatial coordinates in the local metric are just measurements of the particle's position relative to the Dark Star, but the cosmological spatial coordinates are measurements of the temperature poles cast by the CMB on the Cosmosphere. So even if the particle has very high local speed and rotation relative to the Dark Star, if the dipoles and quadrupoles observed on the Cosmosphere by the Dark Star are unchanging, then the particle's cosmological $dt$ and $d\Omega$ are negligible in the external metric.

Thus, we see that Equation 1 describes the motion of the particle relative to the Dark Star while Equation 2 describes the motion of the Cosmosphere relative to the CMB. As the Universe approaches the singularity, the Cosmosphere approaches the temporal center of the external metric. The light shining on it dims to nothing and the particle's motion also stops completely as has been previously discussed. The Cosmosphere moves through the origin of the temporal sphere and begins moving backwards in time (increasing $r$) in a direction oriented $180^o$ to the direction it entered the center. As the collapse progresses, the Cosmosphere gets lit up hotter and hotter over time, the particle moves faster and faster, eventually escaping the Dark Star and the Dark Star itself evaporates as described in section IX. This happens across the infinite Universe until it returns to the hot dense state in which it began and annihilates with the anti-Universe hurdling toward it.

In the next section, we will see how to combine the proper times of both metrics to get the total proper time of the particle.

## XII. TOTAL PROPER TIME

The proper time in Equation 1 implicitly assumes the local gravitational field is in a co-moving cosmological frame. This is because $t'$ is a function of cosmological time $r$. In fact, we know that as $r' \to \infty$ the proper time interval of the co-moving observer $d\tau$ has to be equal to the $t'$ interval, we can choose $dt'$ to be $dt' = d\tau_{co-moving}$. But there is no reference to the spacelike $t$ and $\Omega$ cosmological dimensions in the internal metric. If the gravitational field has cosmological motion, the true proper time will be dilated relative to Equation 1. The total proper time interval is found by multiplying $d\tau'$ by the ratio of $\frac{d\tau}{dr}$ for the actual cosmological motion of the frame (Cosmosphere motion) and $\frac{d\tau}{dr}$ of a co-moving frame:

$$d\tau_{tot} = d\tau' \frac{d\tau}{dr}\left(\frac{dr}{d\tau}\right)_{co-moving} \tag{32}$$

Which becomes:

$$d\tau_{tot} = d\tau' \sqrt{1 - \left(a^2 \frac{dt}{dr}\right)^2 - \left(ar\frac{d\Omega}{dr}\right)^2} \tag{33}$$

Recognizing that $\frac{1}{a^2}$ is the linear cosmological speed of light (Equation 5), we can define $\frac{dt}{dr} \equiv v$ and the cosmological linear speed of light $\frac{1}{a^2} \equiv v_c$. We also define the angular speed $\frac{d\Omega}{dr} \equiv \omega$ and the cosmological angular null geodesic as $\frac{1}{ar} = \omega_c$ (by solving for $\frac{d\Omega}{dr}$ in Equation 2 with $d\tau = dt = 0$), then we can write Equation 33 as:

$$d\tau_{tot} = d\tau' \sqrt{1 - \left(\frac{v}{v_c}\right)^2 - \left(\frac{\omega}{\omega_c}\right)^2} \tag{34}$$

If we multiply $\frac{\omega}{\omega_c}$ by $\frac{r}{r}$, and recognize that $\left(\frac{v}{v_c}\right)^2 + \left(\frac{r\omega}{r\omega_c}\right)^2 \equiv V^2$ is the total cosmological velocity (because $r\omega$ is the tangential velocity which is perpendicular to the linear velocity), then we recover the Minkowski form of the length contraction equation where the speed of light (and therefore the speed of the object in motion) varies over cosmological time:

$$d\tau_{tot} = d\tau' \sqrt{1 - V^2} \tag{35}$$

This is telling us that the worldlines in the local metrics are contracted by the system's cosmological motion. So we see that the cosmological model is essentially a collection of local systems described by real metrics (like the external Schwarzschild metric) in a background that is a quasi-Minkowski metric with a time dependant speed of light.

## XIII. INTERNAL METRIC WORLDLINES

We will now examine the worldlines of a particle in the Universe from its creation at the beginning of expansion to the end of collapse. We know from Equation 6 that the worldline becomes null at the end of collapse, so by symmetry, it will begin the expansion as a null geodesic as well at $t = -\infty$ on the upper left to lower right Pair Production/Annihilation line in Figure 9. It enters the singularity parallel to the $t$ coordinate per Equation 6 (it is shown in Figure 9 entering $t = 0$, but it could be any $t$). At the singularity, it is at the center of the spherical time metric. It will pass through the center and begin to move from $r = 0$ to increasing $r$ during the collapse. However, since it has passed through the center of the

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metric, it is now moving in a direction oriented 180$^o$ from the direction it was falling in during the collapse, again parallel to the $t$ coordinate. It is then accelerated to become a null geodesic as it approaches the annihilation event at the end of collapse. This is depicted in Figure 9 below for both the Universe and anti-Universe (the solid lines are Universe worldlines and the dotted lines are anti-Universe worldlines):

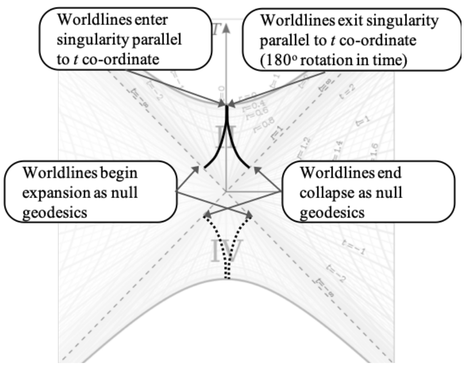


FIG. 9. Example Internal Worldline

We can now put everything together showing the matter and antimatter worldlines in the Universe and anti-Universe for both the internal and external metrics on a single diagram to show the full symmetry of space and time in this model.

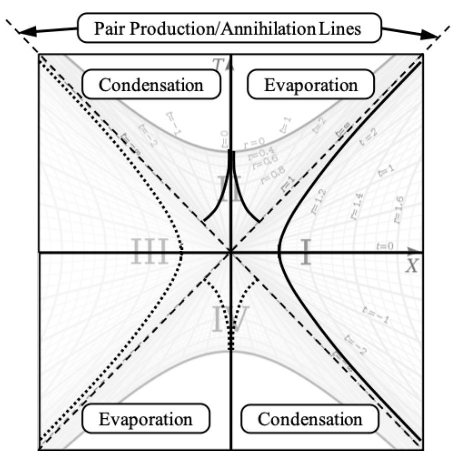


FIG. 10. Full Symmetry of the Schwarzschild Metric

All points on the pair production and annihilation lines are coincident because they are all at the same $r$ coordinate and the proper distance and time separating the points on the lines are zero since they are null geodesics. Note that the worldlines of the external metric approach the pair production and annihilation lines asymptotically, becoming light-like in both cases. So in the upper left and lower right quadrants we see the condensation (or expansion) phase for the matter and antimatter worldlines in both the internal and external spacetimes. Likewise, the upper right and lower left quadrants show the same for the evaporation (or collapse) phase.

## XIV. RELATIVISTIC ENERGY AND INERTIA

The relativistic total energy equation for a particle in Minkowski space is given as:

$$E^2 = (mc^2)^2 + (pc)^2 \quad (36)$$

It is important to note here that $c$ is really just a unit conversion constant that determines how the time and space units are scaled relative to each other, which is different than the physical speed of light from Equation 5, which we will call $v_c$. Therefore, we can think of Equation 5 as being unitless and multiplying it by the constant $c$ just gives it the desired units for space and time.

As we have seen in section XIII, all matter starts expansion on lightlike trajectories, as though they are massless and end expansion fixed to a $t$ coordinate as if their mass has become infinite at the singularity. So $E = mc^2$, which quantifies the energy of a body at rest in Minkowski spacetime, can be more generally written as $E = m_0(v_c c)^2$ for a co-moving observer in the actual Universe where $m_0$ is a constant representing the mass of the particle in empty space when $a = v_c = 1$. Therefore, we can rewrite Equation 36 more generally as:

$$E^2 = (m_0 v_c^2 c^2)^2 + (pc)^2 \quad (37)$$

Noting that $E_0 = m_0 c^2$ (the particle's rest energy when $a = v_c = 1$), we can define the dynamic inertia $m$ of the particle as:

$$m \equiv \frac{E_0}{(v_c c)^2} = \frac{m_0}{v_c^2} = m_0 a^4 \quad (38)$$

What we see from this section and section IX is that gravitational mass and inertia are in fact not equivalent. The gravitational mass depends only on the amount of material in the body ($m_0$) whereas the inertia depends on the Universe's position in cosmological time in addition to the gravitational mass.

It is also interesting, though perhaps not significant, to note that $a \propto \frac{1}{T_{CMB}}$ (where $T_{CMB}$ is the measured CMB temperature at a given cosmological time) and therefore the specific rest energy of particles is proportional to the temperature of the Universe by $\frac{E}{m_0} = \frac{1}{a^4} \propto T_{CMB}^4$ so with $c = 1$ we get:

$$\frac{E}{m_0} = \left(\frac{T_{CMB}}{T_{CMB,0}}\right)^4 \quad (39)$$

## XV. DARK MATTER, THE FERMI PARADOX, 'SPAGHETTIFICATION', AND A SELF PORTRAIT OF THE UNIVERSE

We will now take a closer look at the meaning of the angular term of the internal metric $d\Omega$ as well as what actually happens at the singularity in the cosmological context. When approaching the singularity, the $d\Omega$ term vanishes and proper distances go to infinity. This is often referred to as 'spaghettification'. In the conventional context of falling into a Black Hole, this is interpreted as an observer approaching the singularity getting both infinitely stretched and squeezed and then they just cease to exist at the singularity. But when we interpret the internal metric as the cosmological solution, we find that the true nature of the metric behavior at the singularity is in fact much more mundane, yet incredibly revealing.

We've established that our galaxy is currently at some temporal radius $r$, position $t$ and angle $\Omega$ in the metric. For simplicity in the following discussion, we will assume all objects in the Universe are co-moving, though in reality that is not the case. This assumption is only needed to make the argument clear in this case. We will define the location $t = \theta = \phi = 0$ and $r = r_0$ as the position of the center of our Cosmosphere ($\theta$ and $\phi$ are the angular components of $\Omega$). Now consider two very distant Cosmospheres we observe in the sky that are equidistant from us in polar opposite directions at temporal radius $r > r_0$. We label one Cosmosphere 'Front' and the other 'Back'. Figure 11 shows a diagram of $t$ vs. $r$. The $t$ axis runs from $-\infty$ to $\infty$ and the $r$ axis goes from 0 to $u$. Because $r$ is a radius, the $r$ axis to the right of the $t$ axis points in the direction $\theta = \phi = 0$ and to the left axis it points in the direction $\phi = 0$ and $\theta = 180^o$. The dashed lines are null geodesics that the light travels from the Front and Back Cosmospheres to reach us. The geodesics are drawn as straight lines here, but in reality, they would have some curvature to them due to the scale factor $a$. Our position is the point at $r_0$. The Front and Back Cosmospheres are represented with their own ovals. The upper point in the Front Cosmosphere and lower point in the Back Cosmosphere represent matter or 'Dark Galaxies' that are at the same $r$ and $\Omega$ as the center points, but shifted in $t$.

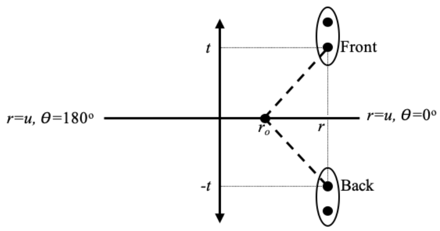


FIG. 11. $t$ vs. $r$

Since we are the point at $r = r_0$, we can see the two points closest to us in the Front and Back Cosmospheres because we are connected to them with null geodesics, but all the other points are invisible to us at the current time and location. Thus, we cannot see the more distant matter at those points because of that non-null spacetime separation. Nonetheless, their gravitational influence on the visible matter in the Front and Back Cosmospheres is apparent to all points. Note that in this special scenario where we are assuming everything is co-moving, there can be no matter between 0 and $t$ or 0 and $-t$ at $r$ because if there were any matter there, we would see those points instead of the ones we see in Figure 11, but we would see them not at $r$ but at some time between $r$ and $r_0$. This is perhaps the nature of Dark Matter. It may simply ordinary matter that we cannot see from our vantage point because of our relative location in spacetime. So matter that is not visible to us would be visible from other locations and times in the Universe and vice versa.

All other observers at $r = r_0$ and $t = 0$ but differing $\phi$ and $\theta$ see all the same galaxies that we do, but they seem them from different angles. So if we are looking at a particular galaxy, our polar opposite observer at $r = r_0$, $t = 0$, $\phi = 0$, and $\theta = 180^o$ will see the same galaxy, but they will see the opposite side of it relative to us. It's difficult to see that on a plot like Figure 11, but we can deduce it because in Figure 11, the light rays reaching us can only come from one side of the Cosmosphere. But the Cosmosphere radiates in all directions, and all those rays must move toward $r = r_0$ because $r$ is the time dimension (i.e. the light moves into the future in all directions). So if for instance the ray coming to us from the Front Cosmosphere has a complimentary ray that radiates in the opposite direction, it must also reach $t = 0$ and $r = r_0$ symmetrically and the only observer fitting that symmetry is our polar opposite. It is an interesting fact of the geometry that at the singularity, we will become coincident with observers that naively seem to be on the other side of galaxies that are expanding away from us. As will be shown, however, even when we are coincident at $r = 0$, we will not 'collide' with these observers because the speed of light is zero there and thus there are no interactions at that point.

Suppose we wanted to travel to our polar opposite observer. If we tried travelling directly toward the Front or Back Cosmospheres to get there, we would not reach our polar opposite because we would be changing our position in $t$ in that case (and both we and our polar opposite are at $t = 0$). We would instead need to take a path where $dt = 0$ and $d\theta = 180^o$. What would the Universe look like along that path? First, let's point ourselves toward the Front Cosmosphere and take the path. In the first scenario, we would be moving along the path as well as spinning because we are keeping our orientation fixed toward the Front Cosmosphere during the transit. What we would see in this case would be all all the Cosmospheres in the Universe spin $180^o$ in place about the rotation axis of the path so that we see them all from the opposite angle when we reach the polar opposite observer. At the end of the path, we would be at the same position as our polar opposite. We would also see a quadrupole on the CMB due to our spinning during transit as described in section XI. If we didn't spin during the transit, but instead kept our orientation fixed as we travelled along the angular path, we would again see the Cosmospheres rotating as before, but we would also see the entire Universe revolve $180^o$ around us. So in

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this case, when we reach our polar opposite, we would be facing the Back Cosmosphere instead of the Front Cosmosphere that we were facing at the beginning of the transit. We would not see a quadrupole on the CMB in this case since we were not spinning during transit. The proper distance separating us would be $s = \pi r_0$ (which would be approximately 42.4 billion light years at our current cosmological time). So a pure displacement in $\Omega$ changes the angle from which we see all the visible matter in the Universe and a pure displacement in $t$ changes which matter is visible and which is dark to us.

This model of Dark Matter may even go as far as resolving the Fermi paradox since there could very well be abundant life not only in our galaxy, but spread across the Universe that is simply undetectable to us because any signals they emit would be invisible to us.

But now we move on to the singularity. Figure 12 shows the light cone angle $\psi$ as function of $r$ as we move along the $r$ axis with decreasing $r$ along the direction $\theta = 0$, through the singularity, and then in increasing $r$ along the direction $\theta = 180^o$.

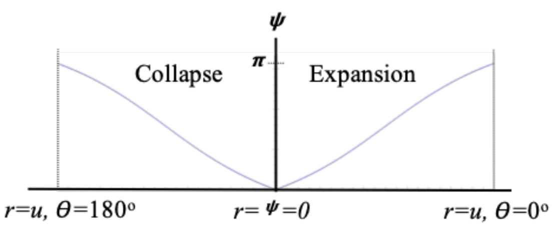


FIG. 12. Local light cone angles over time

We begin expansion at the right side of the diagram where the light cone is totally open ($\psi = \pi$), because Equation 5 goes to $\infty$ there. As we move through time, the angle closes until at the singularity, light no longer travels through $t$ ($\psi = 0$), which is why Equation 5 goes to zero there. At the singularity, light no longer travels through space and everything becomes spacelike. But also recall that motion has stopped at this point and all light is infinitely redshifted, so there isn't really a physical stretch happening, its only that adjacent points in space are unable to communicate with each other at that instant. Also note that if there are different galaxies approaching the singularity at $t = 0$ from different directions, they would only affect us gravitationally (i.e. we would not suddenly 'collide' with them) because they would be spacelike to us. Then as we pass the singularity and continue moving now with increasing $r$ in the $\theta = 180^o$ direction during collapse, the light cone will start opening in a symmetric way to how it closed during expansion.

Finally, let us return to Equation 3 and track the proper distance of a point a fixed coordinate distance $t$ away from us for the duration of the expansion and collapse. If we plot this proper distance vs the imaginary version of $r = ir'$ similar to what was done in Figure 7, we get a clean picture of how the expansion and collapse of the Universe would appear to a co-moving observer (expansion and collapse proceeds from top to bottom). The reader's current position is marked with '**x**':

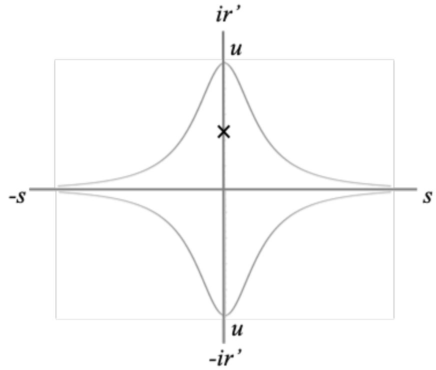


FIG. 13. Self Portrait of the Expansion and Collapse of the Universe with the Reader's Current Position Marked with 'x'

Note that this is not the Universe and anti-Universe. When the Universe is at $r = ir' = u$, that is where the Duoverse collides.

## XVI. THE MANY WORLDS

The Duoverse described thus far contains all the events in the Universe and anti-Universe for a single expansion from beginning to end. However, the Duoverse then recollapses, annihilates, and pair produces a brand new Duoverse. Therefore, we can think of each successive expansion and contraction of the Duoverse as happening along another dimension which is discrete. This dimension essentially labels the different countably infinite random set of Duoverses.

Since each Duoverse begins with annihilation, this means each Duoverse begins with a random configuration after annihilation. Therefore, there is no cause and effect relationship between Duoverses from cycle to cycle. This means the cycles cannot be ordered sequentially because there is no way to know which cycle preceded or will follow the current cycle. If we cannot order the cycles in a sequence, then we can think of them all as being parallel to each other. While events within a cycle can have cause and effect relationships (i.e. the events 'happen' at given times), the various cycles themselves do not 'happen', they just exist along side all other cycles. Thus we can think of the annihilation events as being *a single* event from which infinite Duoverses emerge and to which they return. This implies that finding ourselves in a particular Duoverse is completely probabilistic where the probability that we find ourselves in a Duoverse with a particular configuration depends on how likely that configuration is across all possible configurations. This gives us the many worlds that have been invoked to explain quantum

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probability in the Everett many worlds interpretation of QM.

## XVII. THE CHARGE AND SPIN HYPOTHESIS

Given that the matter and antimatter Universes are moving in opposite directions in time, we can hypothesize that the relative electric charges of matter and antimatter particles are related to the orientation of the particle's temporal velocity vector along $r$. This could perhaps be understood as differences in the directions of group and phase velocities of the wave function in time:

1. *Matter particles in matter Universe*: Group and phase velocities pointed in the same direction toward positive time.

2. *Antiparticles in matter Universe*: Group velocity pointed in positive time direction, phase velocity pointed in negative time direction.

3. *Antimatter particles in antimatter Universe*: Group and phase velocities pointed in the same direction toward negative time.

4. *Matter particles in antimatter Universe*: Group velocity pointed in negative time direction, phase velocity pointed in positive time direction.

We can extend this hypothesis further by considering quantum spin. Electron spin, for example, can be measured to be either spin up or spin down. We could interpret the spin to be a physical spin about $r$ with, for instance, spin up indicating the spin vector is parallel to the time radius of the matter Universe, and spin down indicating the spin vector is anti-parallel to the time radius of the matter Universe. Treating Quantum spin as a rotation about the time axis could be seen as a necessary consequence of relativity: if space and time are truly equivalent, then the possibility of rotations about an axis in space implies that it is also possible to rotate about an axis of time.

More generally, we can posit that the imaginary parts of the quantum wave functions are vibrations of the wave function in the $r$ and $t$ (i.e. $ir'$ and $it'$) dimensions of the internal metric.

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