Krogh Quantum Gravity Explicitly Predicts Hubble Redshift Curve and JWST Findings without Expansion

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JWST finds too many galaxies, too bright, and mature, while surface brightness and angular diameter distance support Euclidean geometry without expansion. Redshift fits an exponential time decay equation perfectly, inconsistent with expansion. We propose a cosmology replacing GR with Krogh gravity theory, where gravity changes quantum vacuum rather than geometry. Using cosmological principle and gravity dependency of terms in governing differential equation, we solve for time variable potential since matter creation. Redshift occurs at emission at earlier potential and light speed. The exponential redshift equation is explicitly derived. It is not tired light. We predict wavelength of past spectral lines, which when measured reveal emission time. Using solved variable light speed, we integrate to calculate distance to present explicitly deriving new Hubble curve. No other cosmology can make this claim remaining free of *ad hoc* parameters. Gravity propagation begins after hot matter creation determining variable light speed, particle mass, and physical constants. Cooling is achieved by increasing mass with momentum conservation. Galaxies form over about 450 billion atomic years or 49 billion present years after CMB recombination surface of last scattering. Krogh gravity as updated remains consistent with successful GR tests and predicts testable new dynamics not predicted by GR. These include observed acceleration anomalies for Earth flybys, JUNO Jupiter orbiter, Pioneer Probe, superluminal galactic jet acceleration, galaxy dynamics, and faster black hole accretion. Spiral star paths explain MOND illusion and ring galaxy formation. JWST mature galaxies require older universe, while galactic jets confirm predicted past higher light speed. Required mass density supports prolific star formation. Many stars and galaxies are likely now dead or consumed by black holes, so invisible baryon mass is expected to be greater than visible mass.

1 Introduction

We propose a new cosmology framework without expansion based on revisions to General Relativity. For such a paradigm change to be accepted we must recognize that existing Big Bang cosmology based on General Relativity is not supported by recent JWST (James Webb Space Telescope) observations. Our new framework adopts Kris Krogh gravity theory removing inconsistencies without requiring any *ad hoc* parameters. The new gravity theory satisfies tests previously thought to confirm General Relativity. In addition, it makes new testable dynamic predictions that General Relativity does not. Despite the unquestionable success of General Relativity, it appears to have flaws in approach resulting in failures especially important as applied to the entire universe.

The cosmology we propose is not new to us. It was developed mostly about two decades ago, however until now remained unpublished. Since it replaces General Relativity and consensus Big Bang-based cosmology both accepted science for about a century, it was clear that a very compelling case was required for such a new paradigm to become accepted. The change at some point will also affect particle physics. Particle properties change with gravity potential, and according to Krogh theory energy no longer gravitates, therefore particle masses have no energy contribution to mass since General Relativity no longer applies. Since the new gravity theory is linked to quantum vacuum change rather than curvature of space, it is consistent with a quantum approach to gravity. Considering JWST findings, a new approach not in tension with observations but instead predicting them is due. We will show that our framework supports these observations. Compelling evidence justifies a new paradigm which is the purpose of this work.

To understand what we propose it will be necessary to have at least a working understanding of revisions to General Relativity adopted here from the work of Kris Krogh [1, 2]. This new cosmology framework would not have been possible without the Krogh gravitational theory with his new approach and perspective. We will not try to repeat here any complete discussion of the Krogh theory but will adopt important features and perspectives needed to develop a more rigorous cosmology solution. In some respects, the Krogh theory of gravity is presently incomplete in its published form notably that the original presentation does not include frame dragging predicted by GR and confirmed since by Gravity Probe B. This will be corrected and updated later but fortunately these changes will not affect our cosmology solution. We will provide further conclusions not mentioned in Krogh's original papers but useful in this discussion to support the cosmology.

In the Krogh approach, most physical constants including the speed of light change with the intensity of the gravity potential both locally and cosmologically for the entire universe over time. Krogh does not presently include how every physical constant varies, so the theory needs some additions for completeness. The most important addition we need is the universal gravity constant G. It turns out that for us to have a consistent cosmology solution including our new Hubble constant counterpart for the redshift versus distance relationship we require that the product GM be constant in an absolute sense even though it is a dimensional quantity. Since mass of bodies or particles are not constant with changing gravity potential in his theory, we require that G varies inversely with mass. Krogh concurs with this though using different arguments, so this addition is a necessary assumption we adopt here.

The Krogh gravity theory has outcomes consistent with GR for past successful predictions. It however has an entirely different perspective in its approach. GR was essentially developed with the view that all physics is local while the effect of gravity is to curve the geometry of space. Its effects extend everywhere in surrounding space time. Included in this perspective is the shrinking of measuring sticks and expansion of geometric space. The Big Bang cosmology rests on solutions to the entirety of space time essentially extending the locally based perspective to infinity. The present Lambda Cold Dark Matter consensus cosmology includes *ad hoc* gravity contributions from non-existent dark matter and dark energy for no other reason other than it would otherwise fail. We claim that the GR perspective still has remaining serious flaws when extended to the entirety of the universe. The most notable flaw is that it requires expansion of space at all where now we have evidence this cannot be the case despite the observed redshift.

In the Krogh theory physical measuring sticks still change as do emitted spectral wave lengths as the gravity potential changes in space or time, but space itself does not change. Space is defined only by mathematical coordinates which are absolute. Geometry of space is always flat, consists of nothing, and does not care what the gravity potential is. The vacuum as we know from quantum theory is not empty but teaming with virtual particles with fleeting existence. The vacuum does care what gravity potential is and its particles reflect the potential energy as does any real matter in space.

Applying a new viewpoint, the Krogh theory comes from the perspective that all physics depends on the entire universe. It is more Mach-like since inertia depends on the entirety of all gravitational mass. We cannot extend the apparent local constancy of speed of light to the entire universe over all time, but instead the light speed depends on the increasing size and location of the observable mass in the entire universe. The gravitationally observable universe has a very large but finite maximum size determined by the unknown extremely high primordial light speed at the matter creation epoch. We cannot observe radiation from anything further than the last scattering surface of the CMB. This observable radiation sphere is a small fraction of the volume of the gravitation observation horizon for all mass in the entire universe. The universe can never collapse because any location in the universe cannot be influenced beyond the symmetric finite gravity horizon sphere. Gravity gradients can only be from more local and nearby mass concentrations. All the above are automatic consequences coming as a direct result of the exact solution to the governing gravity equation. It is not based on speculations. We see that this perspective is entirely different from GR as applied to the whole universe.

With the Krogh perspective, gravity does not curve space time, but the gravity potential changes vacuum properties including particle energy and mass, speed of light and physical constants. In effect the laws of physics though similar are different at different locations and times. The particle mass increases while speed of light decreases in a manner such that the rest energy of the particles reflects any loss of potential energy. For this reason, energy not in the form of mass is not a source of gravitation as in GR since energy conservation arguments do not require it. We claim that photons are massless and not a source of gravity. Light is still redshifted in transit from mass sources because there is a light speed gradient associated with a gravity potential gradient.

All particles under the influence of a gravity potential, including vacuum virtual ones, change not only by increasing mass but also shrink in size as in GR theory. Similarly, there is a slowing rate of atomic time with increasing potential. We could say from this perspective that the vacuum particles are the carriers of the gravity potential. A gradient in potential is not a force, but apparently causes acceleration of masses due to their interaction with a quantum vacuum gradient. Apparently, the gravity potential field residing in space is a direct result of this interaction of matter with the quantum vacuum. The speed of light change results from changes in the vacuum state and gravity propagates at the same speed.

We see further from the new perspective that since particles shrink with increasing gravity potential, measuring sticks used to determine the distance between points in space also shrink. This is consistent with GR, but in the revised view we do not claim that space has shrunk with the sticks. If we use sticks to measure distance between points in space, where in our case potential is increasing negatively forever in time cosmologically, we would conclude that space is expanding, which is not the case.

If we use the wavelength of a spectral line in the current time and gravity potential it does not have the same length as a past much earlier emission. If we observe a distant spectral line and falsely assume it had the same wavelength as a local one, we would perceive that it has stretched in length, but in reality it was longer when emitted. When we measure the emitted length, it tells us the time of emission since we have the solution for how potential varies with time, we also know how light speed varies with time and can therefore calculate the distance from emission exactly by integration. This is a tremendous advantage of this perspective, which is testable and depends on only one free parameter, the average matter density, or the equivalent Hubble constant. Distance versus redshift is inherently non-linear without the need for dark energy. No competing cosmology can make this claim. We now have a perfect explanation for how the universe exists in flat Euclidean space while producing a redshift of spectral lines from the past without requiring tired light in transit or expansion.

Cosmologies based on GR Big Bang expansion have for many decades been the only cosmologies that could come close enough to satisfying observational tests, but only at the expense of introduction of *ad hoc* assumptions, which themselves have no empirical basis for existence were it not for the need for an acceptable cosmology outcome. These include inflation, dark matter, and dark energy, No one knows what these are or can verify their existence despite great expense invested.

The *ad hoc* entities needed to sustain Big Bang-based cosmologies remain as consensus for the sole reason that all previous alternatives have not withstood observational requirements. To some extent, the situation can be justified because we could not abandon the scientific need to understand the nature and history of our universe and working models were needed in order that research in this regard could continue. Cosmology cannot legitimately claim to fulfill the normal scientific process of adopting a hypothesis that is testable and predicting outcomes of observations. Instead, we have for the most part hypothesized things not proven but needed to sustain a working theory of cosmology. The current Lambda Cold Dark Matter consensus has so many *ad hoc* free parameters that it is little more than a curve fit of the observations rather than a prediction from theory. Without introduction of new unsupported parameters, the Big Bang model fails to adequately match observations. Cosmology is a science which does not support introduction of new experiments since we have only one universe. All events occurred in the past and we only observe the present location and time resulting in limited ability to test any theory.

We claim that our proposed cosmology framework has no *ad hoc* parameters. The only free parameters are primordial speed of light and average matter density of the universe. These are simply the initial boundary conditions necessary to apply the general solution of the governing gravity differential equation to the real universe. As it turns out the cosmology is only sensitive to average density if initial speed of light is sufficiently high. Average density determines the effective Hubble constant for the redshift versus distance but other effects on the dynamics of bodies in motion cause important changes in long time frames and high velocities such as in galaxy rotation. There is no longer any need for dark matter or dark energy within our new framework.

The cosmology must withstand observational tests including redshift versus distance and observed uniform smooth black body radiation from the CMB. The proposed framework has no *ad hoc* inflation like the Big Bang required to explain smoothness of CMB since the initial order of magnitude higher light speed would automatically smooth the background observed. The matter epoch must be hot in either case since particle creation can have no preferred inertial frame and is limited only by the speed of light. With a very high speed limit and no preferred direction, creation of particles inevitably results in a very hot plasma. If nucleosynthesis is involved extremely hot initial conditions are required. It can be noted that the universal light speed with no preferred direction establishes a universal rest frame based on the average velocity of zero as for the observed CMB background radiation.

Although matter is created hot it cannot remain so and still produce stars and galaxies. Prior to that it must cool to recombination temperature to produce a surface of last scattering for the observed CMB. There is no expansion as in the Big Bang to cool the universe rapidly, but instead all created particles will slow by conservation of momentum as the universal gravity potential increases. Mass of particles increases which requires their velocity to decrease. The result is cooling but it takes many Hubble times, far longer than the Big Bang. Particles not only have decreasing rest energy, but also decreasing kinetic energy. Eventually the last scattering surface becomes observable as the CMB after recombination temperature is reached and its spectrum is black body radiation not spectral lines. The emitted wavelength is far longer than expected because light speed is orders of magnitude higher. If we know the recombination temperature, we know both the light speed and the time, so we can again integrate for the current distance at today's light speed. It is observed as 2.7 K black body radiation proportional to light speed ratio at recombination temperature.

The solution is gravitationally stable but time dependent. It requires a finite age after the matter epoch. Finite age with a matter epoch is a condition also shared with any Big Bang-based cosmology. It should be pointed out here that finite age should be considered the only acceptable assumption for any cosmology, since we still have stars burning today and they have finite age. If matter were continually created to provide newer stars, then infinite age would produce infinite matter. Any notion of expanding space does not change the proportional density of dead stars. Similarly, we exclude any recycling star assumptions because the process could not be reversible. Infinite age would also make the CMB observation problematic. We do expect in our case that most stars are already dead or consumed by black holes because of the extremely old universe we predict.

With these arguments, only cosmologies with finite age can rationally be considered as candidates. This leaves us with the proposed framework we introduce here, or some variation of Big Bang-based concepts. The distinction between the two is that the Big Bang and General Relativity require that space is expanding and the cause of observed cosmological redshift. Furthermore, it requires that the finite age must not be greater than the time going back to the singularity where space vanishes. This limits the age to the classical Hubble time on the order of 13.8 billion years. Our new framework conversely requires that age is an order of magnitude greater, several Hubble times long, just to set up conditions we observe. It also has a cause for redshift vs distance relationships that are natural results of direct solutions to the governing gravity theory and integration of light speed since emission.

We claim especially from observations of the recently deployed JWST that the Big Bang cosmologies are no longer sustainable. We anticipated this would occur, since we have known our solution for over two decades before the telescope launch. It has long been unlikely that the Big Bang consensus could be broken without sufficient evidence to exclude it. One failure now clear is that massive mature galaxies have been observed by JWST including older generation stars and these structures did not have sufficient time to form since the Big Bang as reported by Labbe *et al* [3]. See also Asencio *et al* [4] showing that large galaxy clusters exist with mergers at excessive velocity for consensus cosmology. Since universe age is not severely limited in the proposed framework, these older mature galaxies and clusters are expected, and it is likely that others even older and more distant may be found depending only on the limits of the sensitivity of the telescope.

Another finding of the telescope is an unexpectedly high population of distant galaxies and the appearance that insufficient gas was available to produce the massive galaxies. The cosmology we propose requires far more baryon mass density providing more available mass for stars. Very distant black holes are found with insufficient time in the Big Bang context to form. In the proposed context there is adequate time and new dynamics associated with the revised gravity theory are in play for rapid accretion of matter into black holes. With the Krogh gravity model these high concentrations of mass still exist but are not totally black. Due to the cosmological gravity potential change we will show that entire galaxies will eventually be accreted into their center black hole.

While the above are features of age and available mass that exclude the Big Bang, other observations are available now which exclude expansion at all as a feature of the universe. Based on observed surface brightness with distance shown by Lovyagin *et al* [5] the universe appears consistent with normal Euclidean non-expanding space which is a feature of our cosmology. Similarly, the angular diameter distance appears to be Euclidean [5] which would exclude expansion. The unexpected massive galaxies appearing to be too small as seen by JWST are not unexpected in our cosmology with Euclidean geometry. These are just normal galaxies, not unlike the local ones we see nearby. Another feature of the universe long known is spatial flatness. This is inherent to the revisions to General Relativity adopted here from Krogh [1] . Gravitational lensing still occurs due to changes in refractive index from non-uniform mass distributions. It is not space curvature with this gravity model but refraction as in an optical lens due to light speed variation in space.

Finally, Marosi [6] extends the Hubble curve for higher redshifts versus distance including distant gamma ray bursts concluding that data perfectly fit an exponential equation with time for redshift of spectral lines. While this is normally associated with rejected past tired light proposals, we show this exact equation can be derived from time variation of gravity potential with our cosmology solution. It is not tired light. A further conclusion of Marosi is that the exponential form of the equation cannot be consistent with expansion. Laviolette [5] also performs several cosmology model tests showing that a tired light model is best of those studied. Our cosmology would perform the same as the tired light model. This becomes a strong confirmation of our proposed cosmology and a rejection of Big Bang expansion.

We conclude a case for exclusion of Big Bang expansion cosmologies creates a crisis in cosmology which requires a new paradigm as proposed in this new framework. Conversely, we see at least in these early stages that the proposed cosmology does not share any of the concerns identified with the Big Bang and makes promising testable predictions. There is much work needed to flesh out further analysis and perform extensive testing and modeling before this can become the consensus working model. There remain some details that need to be added before this can be considered a complete theory of the history of the universe which is why we choose to call it a new framework.

This requires the work of many others with necessary modeling and observational assets which we do not have. We strongly encourage others to participate within this framework and to propose additions or modifications. This work cannot move forward without the help of many experts having capabilities and assets up to the task. The solution has been developed with the knowledge of only a couple of now-retired contributors that are advancing in age. We believe that current cosmology has reached a crisis which cannot be fixed within the space expansion paradigm and those invested in that framework need to expand the scope of their efforts in another direction. Similarly, if we find this framework becomes accepted it may be time to reconsider efforts directed toward dark matter and dark energy.

2 Exact cosmology solution

To develop a more rigorous exact cosmology solution, we will begin with the Krogh [1] original governing equation for the gravitational potential. Although Krogh had a proposed solution for the universal time dependent cosmological gravity potential, it is only the asymptotic solution valid for late time epochs near the present. This approximate solution does not satisfy the governing differential equation. In the end his solution is fully adequate for most things we need, but it is useful to show the proof of his approximate solution previously not shown and fully understand its limitations and how it derives from the exact solution. The governing equation for the gravity potential given by Krogh is:

$$\nabla^2\Phi - \frac{1}{c^2}\frac{\partial^2\Phi}{\partial t^2} = 4\pi G\rho\,. \tag{1}$$

Our new cosmology framework derives directly from the application of this differential equation with appropriate assumptions and boundary conditions. The gravity potential Φ represents the resulting potential produced by the mass density ρ. Speed of light is c and gravity constant is G, but in accord with the Krogh gravity theory ρ, c, and G are all dependent on the gravity potential such that the differential equation is nonlinear. We first simplify the equation by assuming that the cosmological principle applies to the universe on large scales since it can be assumed for our purposes to have a uniform mass density everywhere in space at any given universal time.

The existence of a universal time since the beginning of matter creation is a necessary assumption to solve the equation with appropriate boundary conditions. Since we will end up primarily using only the asymptotic solution it should not make much difference if matter was created everywhere instantaneously. It is presumed that the matter epoch had to occur like a state change spreading almost instantaneously. It could for instance be an event such as a change from a false vacuum to a more stable present one.

Just as is the case for the Big Bang cosmologies, there is no detailed explanation for how matter creation occurred or what initiated it. In the context of this theory the primordial light speed had to be so large that even if matter creation began at some local point triggering a state change, the new state bubble would spread so fast that it would be nearly instantaneous. For our purpose then we assume matter was created everywhere in an infinitely large space. Since we assume the cosmological principle, spatial derivatives vanish, universal time is the only remaining independent variable. This eliminates the first term of the governing equation which results in an ordinary differential equation:

$$\frac{d^2\Phi}{dt^2} = -4\pi G\rho c^2\,. \tag{2}$$

The last three terms on the right are all dependent on the gravity potential so we need to apply the other requirements of the Krogh gravity theory to show the correct scaling relationships for these parameters before we can solve the equation. To simplify the equations further we will define the dimensionless gravity potential and what will be shown to be the equivalent Hubble constant as:

$$\phi = \frac{\Phi}{c_0^2}\,; \qquad H_0 = \sqrt{2\pi G_0\rho_0}\,.$$

We will generally use the subscript, 0, throughout to mean the value existing initially when the matter epoch occurred, where in the beginning there was no gravity potential before gravity had propagated over time. Parameters without the subscripts are the time dependent non-constant terms which depend on the gravity potential in accord with the tenets of the Krogh gravity theory. The newly defined equivalent Hubble constant will generally be shown with the subscript, 0, in equations primarily because we want it to be understood that it is in fact a constant with dimensions of inverse time. The solution of the governing differential equation will be dependent on the product of the Hubble constant and time which in effect is dimensionless time.

Atomic time itself depends on the gravity potential in accord with Krogh gravity theory so we must choose a fixed universe time that ticks at a uniform rate for the differential equation to have meaning. When we find the solution, we need to differentiate with respect to time to verify the solution. It is this universal time and not atomic time that is defined in the equation so when differentiating the solution to verify it satisfies the governing equation the product of Hubble constant and time must treat the Hubble constant as a true constant. The subscript definition reminds us to do this. Technically this also implies that the universal time is taken as the time clock rate that existed at matter creation so that the dimensionless time product cancels out the time units. The important thing is that the choice of linear universal time in differentiation or integration uses time units that are at the same epoch assumed for the Hubble constant.

When we address the problem of deriving the Hubble curve for distance versus redshift, we use the present epoch instead of the primordial one. This is convenient in that case because we are looking back from the present to the past emission time and will integrate the light speed forward to the present to determine the distance. We prefer also in this case to use a Hubble constant defined with the current definition of time units of measure. Note that our choice of how the Hubble constant is defined ends up requiring that the matter density of the universe is 4/3 of classical big bang expansion critical density. There is nothing critical here, however, since the choice simply uses the grouping of terms on the right-hand side of the equation which will end up being compatible with how the Hubble constant has been defined classically in the Hubble curve equation shown later.

Listed below we show the scaling of the terms in our differential equation with respect to the dimensionless gravity potential to be substituted into the final form. The speed of light and matter density are directly from the Krogh paper while the gravity constant G is scaled inversely to the density which we have determined is required and in agreement per discussions with Kris Krogh. Primarily what it means is that the mass charge equivalent to electric charge is also to be conserved and the Krogh theory is taken to be gauge invariant such that the laws of physics are the same at any epoch time:

$$c = c_0 e^{2\phi}\,; \qquad G = G_0 e^{3\phi}\,; \qquad \rho = \rho_0 e^{-3\phi}\,.$$

We can now substitute the defined scaling relationships and definitions for terms in the simplified governing equation to write an even simpler form below which includes only the unknown time-dependent dimensionless potential and constant linear universal time variables. The resulting equation is nonlinear but fortunately has an exact solution:

$$\frac{d^2\phi}{dt^2} = -2H_0^2 e^{4\phi}\,.$$

The exact solution below can be verified directly by differentiating the potential twice with respect to time and substituting the solved potential function into the right-hand side:

$$\phi = \frac{1}{2}\ln \operatorname{sech} 2H_0 t\,.$$

We also can substitute our solution for the potential into the scaling relationship for light speed to define the equation for the history of light speed with respect to time obtaining:

$$c = c_0 \operatorname{sech} 2H_0 t\,. \tag{3}$$

Figure 1 illustrates how the universal dimensionless potential varies with respect to the dimensionless time Ht. It is approximately $-Ht$ as was assumed by Krogh [1]. Figure 2 shows how the dimensionless ratio of light speed c/c_0 varies with universe age in Hubble times.

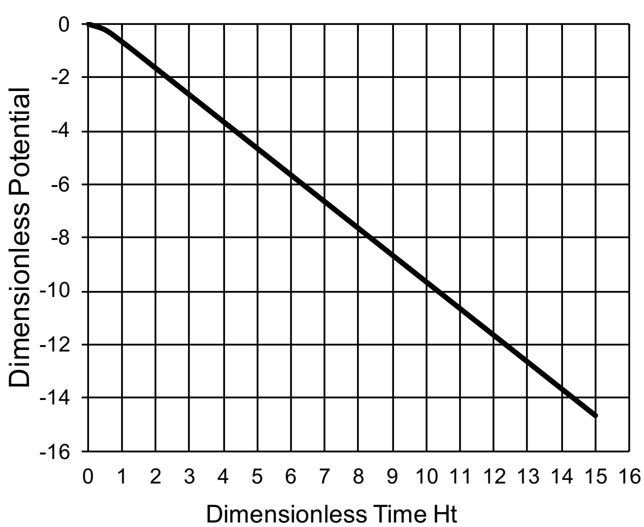

Fig. 1: History of Dimensionless Gravity Potential

Later when we develop the derivation of the Hubble curve resulting from our cosmology framework, we will use a simpler approximate asymptotic equation to integrate the light

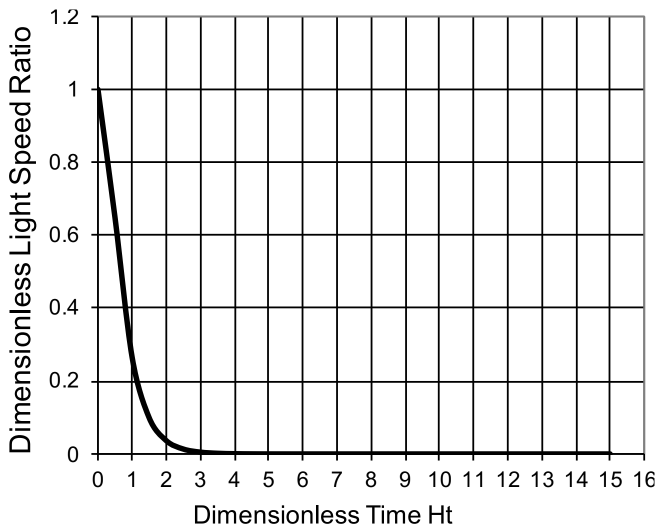

Fig. 2: History of Dimensionless Light Speed c/c_0

speed from emission since the exact solution is unnecessarily complex for late present epoch times. It is useful however to integrate the exact light speed solution from the matter creation epoch to the current time to show the size of the matter horizon from any point in the universe. This is in effect the size of the universe having any effect on any location in the universe. Understanding the enormous distance to the matter horizon is useful to get an understanding for how the average density of matter can be considered constant because it is averaged over a scale far larger than any structural clumping of matter can be. In effect the high light speed at the matter creation epoch was so high that it has a smoothing effect much like the concept of inflation in Big Bang cosmology. This distance is not observable by any means other than this expanding matter horizon is the cause of the present cosmological change in gravity potential. The distance R below from integration of light speed over the history of the universe is:

$$R = \frac{c_0}{2H_0} \arctan \sinh 2H_0 t\,. \tag{4}$$

Interestingly the matter horizon has a maximum radius which cannot be exceeded in infinite time. In the limit as time goes to infinity, the maximum distance light or gravity can travel is:

$$R_{max} = \frac{\pi}{4}\,\frac{c_0}{H_0}\,. \tag{5}$$

It is useful particularly since the primordial light speed is unknown to write the result in non-dimensional form. A plot of the dimensionless ratio of radius over the maximum possible radius, given by (8), is shown in Figure 3. It illustrates how the matter horizon growth causes continual change

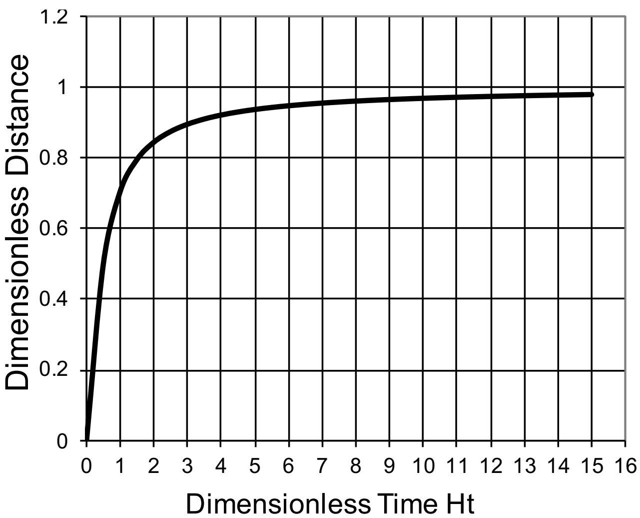

Fig. 3: History of Dimensionless Gravity Horizon

in universal gravity potential:

$$\frac{R}{R_{max}} = \frac{2}{\pi} \arctan \sinh 2H_0 t\,. \tag{6}$$

3 Cosmological redshift types

Now that we have an exact solution for the history of the cosmological gravity potential which results from a matter creation epoch in flat non-expanding space, we can further explain cosmological redshifts which in the past have been the core support for the Big Bang notion that space is expanding in accord with General Relativity. We have adopted the Krogh gravity theory replacing GR where now the effect of gravity does not change the geometry of space but rather the quantum vacuum itself which in turn is fully in charge of the laws of physics, physical constants, light speed, particle mass, etc. Krogh in his original paper [1] defines how atoms residing in the cosmological potential of all the mass in the universe change their atomic spectral emissions. The light speed at emission is directly related to cosmological red shift in accord with scaling of energy at emission along with the associated light speed and gravitational potential. This derives from the Krogh energy equation, which defines energy of past emissions. This implies absolute frequency of emission is higher (blue shifted) at emission due to the lower gravitational potential and higher energy of atoms proportional to the square root of light speed, but the wavelength at emission is stretched in direct proportion to higher light speed. The net result is a red shift in proportion to the square root of light speed. Wavelengths are constant in transit over time at variable light speed since leading and trailing waves move at the same varying light speed. The resulting equation defining the net red shift of atomic spectral emissions with the usual definition for red shift factor z is:

$$\sqrt{\frac{c_e}{c_n}} = \frac{e^{\phi_e}}{e^{\phi_n}} = 1 + z\,. \tag{7}$$

A second kind of redshift comes from the observed 2.7 K blackbody temperature of the CMB. In Big Bang cosmology, this is attributed to expansion of space since emission of a blackbody spectral distribution from the surface of last scattering began following recombination of electrons with atomic nuclei causing the plasma to become transparent following cooling. In the context of the proposed cosmology framework, there is no expansion of space and therefore no rapid cooling of hot primordial plasma is possible. In this case, we will show that cooling still occurs very slowly because all atomic particles are increasing in mass because of the increasingly negative universal gravity potential. To conserve momentum all moving particles will slow down as their mass increases. This is the cause of the observed Pioneer deceleration, so we have confirmation of such cosmological dynamics still occurring at the precent epoch. Since there was no preferred reference frame for the universe at the matter creation epoch, velocities of particles were universally distributed limited only by the speed of light. It is inevitable then that the beginning would be hot with such high particle velocities. We will discuss the changes in dynamics predicted by the Krogh theory of gravity in a later section, but for now we claim that cooling of the primordial plasma continued over many Hubble times before the recombination of atoms occurred to form a surface of last scattering in Big Bang-like fashion.

The blackbody emissions from the surface of last scattering are not associated with any specific spectral lines of atoms as was the case for the previous type of redshift of spectral lines, but instead is an apparent observed temperature obtained from the wavelength peak of a perfect blackbody curve. We need a different model for interpreting what is apparent redshift in the current cosmology framework. The longer wavelengths still occur at emission, but the governing equation is different. Blackbody radiation is defined by a distribution of wavelengths with a peak corresponding to the maximum energy flux. The wavelength at peak intensity for Planck blackbody radiation obeys Wien's law which has the known numerical solution:

$$\lambda_{max} = \frac{hc}{xkT}\,. \tag{8}$$

We know x is a numerical constant and h and k are believed to be independent of gravity potential in the Krogh theory even though they are dimensional quantities. We see from the blackbody law that the peak wavelength depends only on the ratio c/T. Since the peak wavelength cannot change in transit to the observed blackbody temperature of 2.7 K and it was emitted at a presumed temperature of recombination normally taken as 3 000 K, we can write the relationship between light speed and temperature as:

$$\frac{c_e}{c_n} = \frac{T_e}{T_n}\,. \tag{9}$$

Since we know how light speed varies with the universal gravity potential, we can integrate for the distance to spectrally observed redshifted galaxies using (9) and the distance to the CMB from (11)

3.1 Derivation of Hubble curve

Since the exact solution for light speed variation includes the hyperbolic secant, it is unnecessarily complex for simple integration of the light speed to get distances from time of emission to the present observation of redshift based on observations when a much simpler exponential asymptotic solution approximation to the hyperbolic secant is extremely accurate for any emission later than a few Hubble times from the matter creation epoch. It takes many Hubble times to cool the primordial plasma to the recombination temperature for neutral atoms to allow a transparent interstellar space to observe any redshift or for that matter the CMB surface of last scattering beyond which nothing is observable. Thus for purposes of estimating distance versus redshift, we are justified in replacing the hyperbolic secant in the equation for light speed with the exponential asymptotic approximation:

$$c = c_0 \operatorname{sech} 2H_0 t \cong 2c_0\, e^{-2H_0 t}\,. \tag{10}$$

We can determine the theoretical distance to any observation as the integral of light speed from emission to observation. Using our approximation for the hyperbolic secant above we determine the integral:

$$D = \int_{t_e}^{t_n} 2c_0\, e^{-2H_0 t} dt\,. \tag{11}$$

We will use subscripts e for emission and n for now the present time of observation. Since we do not know the time of emission directly, we need to change the result to something we observe or know for the two types of redshifts. The integral of the exponential function just yields the same exponential function as the integrand again, which can then be replaced with the light speed from (12) when evaluating the integral upper and lower limits. The result expressed between limits in terms of light speed ratios becomes:

$$D = \frac{c_0}{2H_0}\left(\frac{c_e}{c_0} - \frac{c_n}{c_0}\right) = \frac{c_n}{2H_0}\left(\frac{c_e}{c_n} - 1\right). \tag{12}$$

We know current light speed and the emitted to present light speed ratio for either type of redshift above. For spectral redshifts of distant galaxies we use (9) to substitute for the observed redshift factor z and obtain the relation for distance versus redshift corresponding to the classic Hubble curve:

$$D = \frac{c_n}{H}\left(z + \frac{z^2}{2}\right). \tag{13}$$

This is like the historical Hubble relationship for distance vs redshift except for the last quadratic term in z. We dispense with using the subscript for H here because H is a dimensional constant with inverse time units, and we must use the same time units for H and the current light speed in the leading term. So, this is the Hubble constant expressed in the units we are familiar with at the current time. We have derived the Hubble curve directly from the new cosmology solution for the time varying universal gravity potential. Note that the extra quadratic term explains the non-linearity of the curve previously thought to be caused by dark energy when GR was used in consensus cosmologies. We do not need any such *ad hoc* parameter here to get the exact solution deriving from the Krogh gravity theory. As a preliminary check for our result, we show in Figure 4 a plot of distance modulus versus redshift obtained using this equation with some old observed distance estimates based on standard candle analysis including supernovas and redshifts for gamma ray bursts. It may be the case that standard candle energy fluxes need to be corrected for evolution with respect to the variable universal gravity potential with time at emission. Nevertheless, we are encouraged to find that we appear to have a credible model for the cosmological redshift of spectral lines without any expansion of space as a cause.

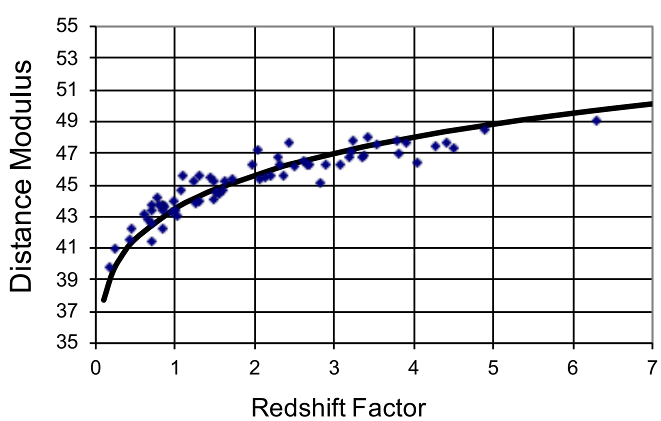

Fig. 4: Distance vs Redshift Factor

3.2 Distance to CMB surface

Using integration of light speed from emission to the present time given in (14) we can substitute the observation implied by temperature of recombination assumed in (11) for apparent redshift of blackbody radiation coming from the surface of last scattering which yields the distance to the CMB. Using the general integration of light speed from emission to the present given in (14) we can substitute the observation implied by temperature of recombination assumed in (11) for the apparent redshift of the blackbody radiation coming from the surface of last scattering which yields the distance to the CMB surface:

$$D = \frac{c_n}{2H}\left(\frac{T_e}{T_n} - 1\right). \tag{14}$$

Assuming temperature of recombination unchanged, the surface of last scattering has a temperature of 3 000 K and the CMB is 2.7 K blackbody radiation. Using (16) we calculate the distance to the CMB surface is about 555 Hubble time light-years at todays speed of light. This is about 7.8 trillion light-years with an assumption of Hubble time of 14 billion years. Present consensus cosmology based on the Big Bang would estimate this surface as about 40 billion light-years away. Our much greater distance estimate occurs because the light speed at emission from the surface of last scattering is orders of magnitude higher than today. The higher light speed is in fact the cause of the apparent redshift. Our use of light-years distance here is just a convention for historical reference. The 7.8 trillion light-years is not the light travel time, which is much shorter due to the earlier higher light speed. We have now set the stage for how much time is available for galaxy formation and distance to the CMB surface giving a visual picture of what we are looking at.

3.3 CMB relationship to Hubble constant

Previous investigations of the angular power spectrum structure of the CMB, according to what we predict, must now consider the surface is orders of magnitude more distant than thought. The universe is not expanding with respect to CMB observed structure. Past modeling of acoustic oscillations would now have to consider far higher speed of sound caused by lower mass of atoms in the plasma. The higher light speed also allows causal contact for far greater distance. Because of the great distance to the CMB surface, observed structures are enormously larger than thought. It also restricts the ability of instruments deployed to resolve smaller structural features of the CMB.

Cosmologists currently in the consensus Big Bang context have tried to estimate the Hubble constant by relating the CMB structure to the expansion of the universe which has resulted in a Hubble constant crisis due to disagreement between estimates based on the CMB versus more direct estimates based on the nearby distance ladder studies. Our new cosmology framework sets a stage which would invalidate prior estimates of the Hubble constant based on the CMB. It may be possible in the new context to estimate the distance to the CMB based on comparison of structure in the present universe compared to the scale of the structure in the CMB. The comparison would have to be made at a very large scale. According to (16), the distance to the CMB surface is inversely proportional to the Hubble constant.

3.4 Cause of uniformity of CMB

The extreme uniformity of the CMB has previously been used to support the concept of inflation as an addendum to the notion of the Big Bang. The argument is that there is a horizon problem due to lack of causal contact at required distances. We have no horizon problem here because the primordial light speed was sufficiently high and there is gravitational contact extending for many Hubble times distance from the CMB surface. Cooling of the primordial plasma as we will discuss later is a very slow process which results from the increasing gravity potential as the gravitational matter horizon grows. The resulting temperature cools very uniformly because it depends on the average density of gravitational matter over enormous distances far away from the CMB. The great length of time for equilibrium is also a benefit.

3.5 Age since CMB surface formation

We calculated the distance of the CMB surface using (16) but our distance of trillions of light-years was not the light transit time which is normally the case with constant light speed. The light transit time with the variable light speed can be calculated from (11) along with the cosmology solution for light speed versus time. Using simpler (12) for a sufficiently accurate relationship for light speed as a function of time and the known ratio of temperatures in (11) we get about 3.5 Hubble times for the required light speed change since the CMB surface formed which gives the light transit time of about 49 billion years. Interestingly this is not greatly different than the 40 billion years expected distance at constant light speed with consensus Big Bang cosmology but in that case the age since the CMB formation is believed to be close to 14 billion years and the distance accounts for presumed expansion. Here it was 49 billion years ago in today's time units in absolute years taken as constant over history. So this is our estimated age of the CMB surface formation time. This means we had 49 billion present years for galaxies to form since the universe cooled. It also means that JWST observed early galaxies had an abundance of time to form and grow old in some cases as well.

3.6 Early time dilation

We are a long way toward setting the stage for what we are in the process of observing in the universe today, however there is an important additional consideration which is significant. The teaching of the Krogh theory of gravity we have adopted along with our cosmology solution says that not only the speed of light and mass of particles was changing with our universal time reference, but atomic clocks have also slowed continuously since the matter creation epoch. This means that processes in the distant past occurred at a much faster pace in atomic time. If we observe an event such as a light curve of an explosion it would appear to be slower because the light speed change is faster than the rate of change speeding up the event in our universal time reality. So events that are actually happening more quickly are observed to be slower or time dilated due to the stretching effect of higher light speed. If we are looking at something caused by age, or which simply takes time like the death of stars it in reality occurs more rapidly in the past. We should not be surprised if things look too old or don't appear to have time to form. We also have seen apparent time dilation in distant events formerly attributed to general relativistic time dilation. Time dilation is a feature of this cosmology as well coming instead from the Krogh gravity theory.

To understand better what we are seeing when observing the most distant galaxies, and therefore the youngest, it is instructive to calculate atomic ages of things we observe. We can now do this by applying our cosmology framework and the Krogh gravity theory teachings. According to the theory, the rate of atomic clocks is greater in the past when the dimensionless potential was a lower negative value. The difference in the potential is positive if we are looking backward to earlier times. Defining atomic time as τ, the relationship for the instantaneous atomic clock differential time interval elapsed in the past compared to the universal constant present time intervals can be written using approximate late time gravity potential as:

$$d\tau = e^{Ht} dt \,. \tag{15}$$

The Hubble constant is in current universal time. Time in the exponent is the time as in years ago past. The total elapsed atomic time can be found by integrating forward to the present:

$$\Delta\tau = \int_0^t e^{Ht} dt = \frac{e^{Ht} - 1}{H} = \frac{z}{H} \,. \tag{16}$$

We obtain our result in terms of the spectral redshift originated from emission at the past time t by applying what we know from (9). This simple result shows elapsed atomic time is given by the product of redshift and the Hubble time. If we apply this equation assuming a Hubble time of 14 billion years, a galaxy observed by JWST at redshift 13 emitted its light about 182 billion years ago in atomic time. In §3.5, we found the distance to the CMB surface of last scattering based on the assumed temperature of recombination is estimated to be at a light travel time of about 49 billion years in constant present years. If spectral emissions were possible at the time of recombination when the CMB surface formed, we can use (11) substituted into (9) to predict that such an emission would have a redshift of about 32. This is the maximum redshift possible if the recombination temperature is 3 000 K. Computing the atomic time elapsed since the recombination time we get about 453 billion years. The difference in atomic time from recombination to the time of a redshift 13 galaxy gives us about 271 billion years available for the formation of the galaxy since the universe cooled to allow formation of stars. We would not be at all surprised if galaxies at this time appeared to be matured in form with signs of age.

4 Impacts of universe age and rate of physical processes

Because we do not know the primordial light speed at zero gravity potential before creation of matter initiated propagation of gravity throughout the universe, we cannot determine its total age. We predict about 49 billion years of current absolute length just since the CMB cooled to recombination temperature. We do expect the matter creation to be very hot if for no other reason that there cannot be a preferred reference frame for the velocity of mass particles created. The cooling process occurs only from conservation of momentum with increasing mass of particles. The cooling model applies from creation through the history of the universe. The mechanism in the absence of expansion is discussed further in §5 as part of a larger narrative about interstellar dynamics resulting from the Krogh gravity theory.

There are profound consequences of orders of magnitude increase in universe age and the accelerated rate of all physical processes at earlier lower gravity potential. The most significant effects occur in the 49 billion absolute years since formation of the CMB surface. After some additional cooling the formation of stars and galaxies begins, and these are the only things we can observe today. Since the rate of physical processes is much faster at early times, the effect of time dilation causes everything we observe today to age more quickly so we can expect evidence of more than 49 billion present years available from our perspective. We determine the 49 billion absolute years by using dimensionless time Ht which comes from the cosmology solution directly. We use units of Hubble constant based on the present which means that the number of Hubble times provides an estimate of age in current years. The number of Hubble times since the beginning is very close to the dimensionless gravity potential as well. Due to nothing else but the coefficients on the right-hand-side of (2) and the definition of the Hubble constant, we know that the total matter density of the universe is 4/3 of the classical Big Bang critical density. There is nothing critical here about the matter density since it is still an arbitrary initial boundary condition for solution of the governing equation. Since we require much more matter than can be accounted for as visible luminous stars, we require that most matter is invisible, but we do not believe that dark matter not consisting of baryons is needed because the effects of advanced age and rate of aging including new interstellar dynamics can be sufficient to produce the total matter density required.

Attempts to find supposed dark matter not made from ordinary baryons have failed to succeed regardless of extensive time and resources expended. So, while mysterious dark matter is not necessarily excluded in our new cosmology framework, it is not required. We will show in §5 that we believe new galaxy dynamics resulting from the Krogh gravity theory can account for galaxy rotation dynamics without any exotic type of matter.

4.1 Real baryonic dark matter

We claim that formation of real baryonic dark matter is a natural process in our new framework caused by both greater actual age predicted, but also from accelerated aging from the time dilation effect of lower gravity potential at earlier times beginning just after formation of CMB surface of last scattering and sufficient cooling to form stars and galaxies. Real dark matter is made up of products of star and galaxy formation and aging along with interstellar gas and dust which has so far not formed stars or been consumed in black holes. The principal products are discussed in the next subsections.

4.2 Star death

We have long known a great deal about how stars form from interstellar gas and dust. Depending on the makeup and mass, stars have various finite ages. Those which become unstable explode producing interstellar dust and remnants. Those which collapse or explode can exist in another state for extended times, but in any case, can remain luminous for only a finite time. The most common stars such as our sun will end up as very dense small white dwarfs which will ultimately cool to dark dwarfs. In the context of current Big Bang age-constrained cosmologies, it is thought that dark dwarfs do not exist in the universe yet because the cooling of a white dwarf star takes many billions of years. The age constraint of 14 billion years from the Big Bang is not sufficient. Dark dwarfs are not likely to be detected if existing because they would no longer be luminous and are only earth-sized very dense objects. With our new framework having 49 billion years available since CMB formation plus highly accelerated aging in the earlier years with far faster atomic time, we would expect to produce prolific populations of dark dwarfs and other types of dark remnants and dust. In fact, it is conceivable that what is thought to be dust in some galaxy photos with back lighting may actually contain large populations of dark dwarfs and remnants as well. We also know that many stars are formed which escape their galaxies and are adrift in interstellar space. These would die of old age in the time available during our 49 billion years and would remain undetectable at present. They would contribute to what may now be perceived as dark matter but there would be no need to claim it is not baryonic. Dead stars are one of the contributors for non-luminous matter we require. Due to accelerated atomic time at ancient times early stars did not last long before they died and became non-luminous. From further discussions we will see that new interstellar dynamics provides mechanisms to further dispose of ancient stars in black holes more quickly than allowed with present dynamic models. These can never be detected or seen again in any form.

4.3 Galaxy death

Astronomers have found galaxies which have stopped forming stars are common. It normally happens whenever there is insufficient interstellar gas remaining in the vicinity of a galaxy to support star formation. Many of these failed galaxies also have supermassive black holes at their centers. In the context of our new framework these galaxies will ultimately die and with sufficient time will be consumed by their black hole center in accord with what we will show. This will be more apparent after we discuss interstellar dynamics changes predicted by the Krogh theory. We have the same situation brought on by advanced universe age and time accelerated aging that we have with individual stars. Here we have entire galaxies collapsing into massive black holes that become undetectable except for gravitational effects such as affected galaxy clusters. It should be noted that gravitational lensing still occurs with Krogh gravity theory, so this is still consistent with observations.

4.4 Black hole formation and growth

The Krogh gravity theory still predicts that highly compact massive objects will form and for all intents and purposes have the characteristics we attribute to black holes in General Relativity. The only difference here is that they are just very gray and not black. They do not radiate sufficiently to be detectable but there is no event horizon. The speed of light can never quite be zero in Krogh gravity. The collapse of massive stars can still result in such black (gray) holes, which we, just for convenience and historical purposes, will refer to as black holes. It is also the case that matter can escape such holes forming galactic jets.

An inherent feature of the new gravity theory is that conservation of momentum will cause orbiting bodies to slow as their mass increases in the intense gravity potential of a black hole. This will cause matter to be accreted by black holes more rapidly than is the case for conventional GR theory. The new dynamics will be discussed in more detail in §5. With the new dynamics predicted not only will black holes accrete matter more quickly, but so also will the motion of stars in galaxies tend to spiral into the gravity well of the galaxy itself. The formation of a black hole at galaxy centers is inevitable with this dynamic if the galaxy is sufficiently large. Cosmological increase in potential also causes stars to spiral into galaxies as a normal process contributing to feeding center black holes. The fate of any galaxy not actively continuing to create stars is to cause stars to spiral into the center black hole. Our new cosmology framework predicts multiple processes have continued throughout the history of the universe which create prolific amounts of invisible baryonic matter. Since non-baryonic dark matter has not been detected, and we require total matter density of 4/3 of classical Big Bang critical density determined by the Hubble constant, it is believed that actual invisible baryonic matter exists in the various invisible forms discussed. We do not believe that any exotic non-baryonic matter is necessary to provide the required total matter density, since the universe is so old that a great deal of matter today cannot be detected other than through gravitational effects.

4.5 JWST findings

Our cosmology framework sets the stage for what we expect to observe with the recently deployed James Webb Space Telescope. We see no findings since JWST went operational that are considered unexpected. In the first year of operation a prolific number of galaxies were seen at great distance. Many were unexpectedly massive or bright, small, old, mature in form, contained older stars, and appeared to have insufficient time to form since the supposed Big Bang. Clearly Big Bang consensus cosmology is not consistent with JWST findings. There is a crisis in cosmology today which cannot be resolved without replacing the GR paradigm which leads to the Big Bang limitation on age of the universe since recombination formed the CMB surface. An extensive discussion of cosmological model tests using JWST findings was done by Lovygin *et al* [5] and further by LaViolette [7]. The key findings are that angular diameter distance and surface brightness do not support an expanding universe paradigm. Euclidean geometry and an alternative explanation for redshift are implied. We provide a new cause for redshift here without tired light.

We have shown here with our new framework that an observed galaxy at redshift 13 has an estimated 271 billion years of atomic time since recombination to form such a galaxy. It seems likely that many galaxies would exist at this redshift detectable by the telescope which are mature and massive, having had more than sufficient time to mature and grow. Furthermore, since we predict far more baryonic gas was available initially, there was no shortage as has been supposed in consensus cosmology models. In fact, based on other considerations of our new interstellar dynamics, black holes would have formed as well. We would expect prolific star formation with plenty of available gas and many star deaths due to both earlier formation and accelerated atomic age. Due to availability of gas, galaxy deaths would be expected to be less common at the earliest times compared to the present.

We predict that galaxies formed at times far more distant than JWST can detect. A key mission of the telescope was to explore the first galaxies formed in the universe. It appears to us that this goal cannot be achieved. Galaxies continue to form through the history of the universe so there will always be some new ones, but we do not expect that the telescope can see the first ones. It is likely that JWST will find fully mature massive galaxies as far away as the limits of its sensitivity allow. This is the inevitable consequence of the much older universe we predict.

5 Interplanetary and interstellar dynamics

We have shown that solving the governing equation for Krogh gravity theory results in a cosmology framework that solves the current crisis between observations and consensus Big Bang cosmology. General Relativity has been the consensus gravity theory for about a century. While providing superior cosmology, the Krogh gravity replacement still satisfies previous GR tests. We also predict new testable dynamics not predicted by GR. Predicting new outcomes in addition to satisfaction of prior tests is necessary to gain acceptance. With that in mind we will discuss the modeling of new dynamics in several examples to follow. The Mercury orbit is included to show that our dynamics model obtains the identical result as GR though it is based on an entirely new paradigm.

There are different approaches that can be taken when following the teachings of the Krogh gravity theory to model the dynamics of bodies in motion under the influence of gravity. The one we will use here is based on strict conservation of momentum while modeling the variation in mass under the influence of a gravity potential as required by the Krogh theory. The rest energy is not conserved because the combination of light speed change and mass results in rest energy changing to reflect the change of potential energy from gravitational potentials produced by either local masses or average cosmological mass density. The fact that all masses in the universe keep track of their potential energy is a key feature of the Krogh gravity paradigm. Conservation of momentum has always been a stronger mandate in physics. Using this mandate results in a slightly different anomalous acceleration math model than previously reported but observable anomalous effects previously not predicted are still indicated. The correct Mercury orbit supports our approach.

The continual growth of the gravitational matter horizon causes a cosmological deceleration of any mass in motion in the universe. This cosmological effect is one type of new dynamics not predicted by GR but clearly required by the Krogh theory. The second type of modified dynamics results from the transport of any mass in motion through a gravity gradient caused by local masses, which alters the universal background time dependent potential satisfying our cosmology solution. A mass in motion does not know the difference between time rate of change of mass from incoming gravity just arriving from the matter horizon since matter creation began or from change due to motion in a local gravity gradient. In the latter case, the gravity potential can either increase or decrease so it can cause either deceleration or acceleration not predicted by GR. Fortunately these predicted modifications to dynamics are testable with sufficiently accurate measurements and in fact have already produced observed anomalous effects. Our choice of modeling new dynamics from conservation of momentum alone works universally for all types of anomalous accelerations which will be discussed next. The approach for motion in local gravity gradients generalizes the fact that anomalous accelerations are caused by the total time derivative of the dimensionless potential locally causing masses to vary with the potential.

5.1 Cosmological deceleration

Cosmological deceleration is an inherent consequence of our cosmology solution from Krogh gravity theory along with its required variation of mass under the influence of the universal gravity potential. If momentum is to be conserved, the velocity must change inversely with the mass change at least in the non-relativistic case. We will develop our dynamic model with the requirement of conservation of momentum including consideration for special relativistic momentum which still applies. This leads to more generality and makes additional predictions of interest.

Beginning with the Lagrangian applicable for the Krogh gravity theory [1] and taking the partial derivative with respect to velocity yields the equation for the relativistic momentum:

$$p = \frac{vE_{00}\, e^{-3\phi}}{c_0^2 \sqrt{1 - (v^2/c_0^2)\, e^{-4\phi}}}\,. \tag{17}$$

In accord with the Krogh definition E_{00} is the rest energy at zero gravity potential and c_0 is light velocity at zero potential. We similarly have the dimensionless gravity potential ϕ as defined. In the cosmology solution, masses are only free of gravity instantaneously at the matter epoch which is an instructive starting point. We can later generalize to more arbitrary epochs. Writing the momentum in terms of mass rather than energy originating from the Lagrangian, the momentum becomes:

$$p = \frac{vm_{00}\, e^{-3\phi}}{\sqrt{1 - (v^2/c_0^2)\, e^{-4\phi}}}\,. \tag{18}$$

From the cosmological solution for the dimensionless potential, we found that it asymptotically became an effective dimensionless time since it converged to $-Ht$. So, our expression for momentum looks like momentum as a function of time for a free particle in straight line motion. But we require that momentum is conserved because there is no external force or acceleration in play. If we take the epoch of the motion as zero potential or time, we require that the momentum is constant. We require the equality:

$$\frac{v_0}{\sqrt{1 - (v_0^2/c_0^2)}} = \frac{v\, e^{-3\phi}}{\sqrt{1 - (v^2/c_0^2)\, e^{-4\phi}}}\,. \tag{19}$$

Terms with subscript zero can be considered as values at an epoch corresponding to zero gravity potential. For now, we will consider how changes affect the motion of all particles in the universe following the matter epoch beginning with zero dimensionless potential. To describe the motion, we can solve for the time-dependent velocity at any arbitrary potential at a time later than the epoch. The velocity at epoch is arbitrary representing all possible velocities that may have existed. We solve for velocity and obtain the function describing the trajectories of particles:

$$v = \frac{v_0\, e^{3\phi}}{\sqrt{1 - (v_0^2/c_0^2) + (v_0^2/c_0^2)\, e^{2\phi}}}\,. \tag{20}$$

Another useful form is obtained by dividing by the local velocity of light on the left side and using the same light velocity scaled from c_0 with the dimensionless potential on the right side to obtain the relationship for the dimensionless velocity ratio:

$$\frac{v}{c} = \frac{(v_0/c_0)\, e^{\phi}}{\sqrt{1 - (v_0^2/c_0^2) + (v_0^2/c_0^2)\, e^{2\phi}}}\,. \tag{21}$$

It is clear from (22) that all particles or bodies in motion are forever slowing as the potential becomes increasing negative in accord with our cosmology solution. The dimensionless potential plays the role of negative dimensionless universal time. Interestingly, (23) shows further that highly relativistic particle velocities near the speed of light tend to slow in proportion to the slowing light speed such that the velocity ratio v/c tends to be more constant. A particle moving at light speed would slow with light speed over time behaving more like a photon. Since there could be no preferred frame for matter creation, some original particles would be highly relativistic and in principle, barring collisions, would still be relativistic at the present time. If it were possible for some particles to survive in the rarified low particle density for many billions of years it would result in a cosmic ray background. In any case, any relativistic particles created later in the universe tend to remain relativistic for as long as they can survive. We will show that there exists a predicted means to create such particles that is a part of our new gravity model.

5.1.1 Cosmological cooling

Our first example of cosmological deceleration is cosmological cooling. We have discussed previously that cosmological cooling plays an important role in our new cosmology framework. Since we no longer have expansion to provide the rapid cooling after matter was created as is the case for the Big Bang, another means is required. Extremely hot matter creation seems to be an inevitable requirement as we have claimed, and cooling is required to form the surface of last scattering for the CMB in similar fashion as supposed in the Big Bang cosmologies. We also require that the universe must cool first to the recombination temperature of the last scattering surface and then additional cooling to allow star and galaxy formation at later times.

Temperature is assumed to be proportional to average kinetic energy of particles which is proportional to mv^2. Both mass and velocity depend on dimensionless potential given by the cosmology solution and our dynamic model conserving momentum. Eq. (22) provides the full relativistic model for velocity dependence on the potential. Since most particles are not at relativistic velocities, we will simplify our cooling model to consider that the average velocities are not relativistic. With this assumption, (22) simplifies to show variation of velocity with the dimensionless potential to become:

$$v = v_0\, e^{3\phi}\,. \qquad (22)$$

So, while velocity decreases with increasing negative potential, mass scales inversely in accord with the Krogh theory. Since velocity is squared for kinetic energy, we can conclude that the temperature of the universe can be expected to cool over time in an otherwise adiabatic universe as the negative gravity potential increases in accord with the cosmology solution so that temperature will obey the scaling equation:

$$T = T_0\, e^{3\phi}\,. \qquad (23)$$

Since the dimensionless potential is basically measured in Hubble times of approximately 14 billion years, after the few Hubble time non-linear start when matter was created, cooling would continue to reduce temperature by a factor of 1 000 over about every 30 billion years. We of course do not know the temperature of the universe at creation except that it had to be extremely high. We therefore can expect that the universe may have taken hundreds of billions of years to cool to the recombination temperature forming the surface of last scattering for the CMB. Because of the high primordial light speed, we can conclude that the matter horizon was already trillions of light-years at present speed from the last scattering surface. We conclude that the great length of time for the universe to reach equilibrium before this surface began and the great distance to the matter horizon source of the gravity potential would result in a very uniform smooth surface dependent on the average density over trillions of light-years. We propose that this rationale explains why the CMB is observed to be remarkably uniform in structure. Neither inflation nor expansion is necessary in the new cosmology framework.

5.1.2 Pioneer probe deceleration anomaly

Although it is unlikely we could observe cosmological cooling to test our dynamic model arising from the Krogh gravity theory and the cosmology solution, we have a surrogate for the effect by virtue of the anomalous observed deceleration of the Pioneer probes. The model applies equally to material bodies, spacecraft, or interstellar particles in motion. Analysis of observed anomalous deceleration is discussed extensively by Anderson [8]. Krogh [2] also has addressed the deceleration as a cosmological effect which we also claim here. Unfortunately, the Pioneer spacecraft are less than perfect as a test of the cosmological effect we predict. The deceleration is very small and can be contaminated by other forces coming from the spacecraft and as we will show there are opposing accelerations which are also predicted to occur from motion through gravity gradients existing in the solar system. Thorough analysis of the Pioneer data is ongoing which will add more than we can discuss here, but for now we want to show from the conservation of momentum model we propose here what the cosmological contribution would be.

We can use (24) which is what conservation of momentum requires for velocity in the non-relativistic free body case to derive the cosmological deceleration contribution for our cosmology model. The acceleration implied by the velocity (24) can be derived by differentiating velocity with respect to time which gives:

$$\frac{dv}{dt} = 3v_0\, e^{3\phi}\, \frac{d\phi}{dt}\,. \qquad (24)$$

Using (24) we can effectively update the epoch for velocity to the local one by substitution:

$$\frac{dv}{dt} = 3v\, \frac{d\phi}{dt}\,. \qquad (25)$$

Since it is sufficient to approximate the dimensionless potential at the present epoch as $-Ht$ according to the cosmology solution, we can write this in terms of the Hubble constant as:

$$\frac{dv}{dt} = -3vH\,. \qquad (26)$$

This result is slightly different than the result given by Krogh [1] since we now have an integer factor 3 as opposed to 4 previously reported. It's clear since we have conserved momentum that the alternative derivation conserving energy did not conserve momentum which is the preference here. We will show modeling motion within the Sun's gravity gradient by planet Mercury that using the factor 3 duplicates the GR result for the rotation of the orbit ellipse. A full treatment of the anomalous acceleration of the Pioneer probes must include effects for motion within solar system gravity gradients.

5.2 Motion modified by gravity gradients

We have shown for the non-relativistic case in (27) that a cosmological deceleration results from the time rate of change of the time dependent dimensionless potential predicted by our cosmology solution. The cosmology solution applied the cosmological principle assuming a uniform average matter density throughout the universe. This of course implies there are no spatial gravity gradients from local gravitational bodies. A body in motion would experience a change in gravity potential due to passage through a local gravity gradient. The body would not know the difference between a change resulting from motion in a local gradient or a time rate of change from the cosmology.

The cause of the anomalous accelerations predicted by the Krogh gravity model arises from conservation of momentum in the presence of changing mass of a moving body. When massive bodies are immersed in a space subject to a spatial gradient of the gravity potential, they also experience gravitational accelerations which are independent of mass since all masses fall at the same acceleration. While the gravitational acceleration can cause momentum to change such that it is no longer conserved as we had assumed in previous derivations, we can still predict that the anomalous accelerations predicted by momentum conservation in the absence of external accelerations will occur because the mass still changes in accord with the Krogh gravity theory as a function of the dimensionless potential regardless of the cause. This effect of momentum conservation from changing mass occurs instantaneously and would be superimposed on accelerations arising from gravity gradients. It follows of course that cosmological deceleration predicted never goes away and is also superimposed as a perturbing anomalous source affecting the total acceleration of any body.

Before we go further, we should address an issue arising because we wish to superimpose dimensionless gravity sources coming from different gauges of reference. We could call this the near far and past present terms in the total gravitational potential. This problem results from the fact that the cosmological time dependent term has a primordial light speed which represents the light speed of an empty universe with no gravity potential and the gravity potentials of local bodies such as the sun or earth generally refer to a light speed far from local gravity fields. It is important to separate the definitions of the light speeds which are regarded to be free of gravity in local settings from the cosmological one where space was only free from gravity at the matter epoch long ago. We need to add non-dimensional potentials which are normally calculated by dividing by the square of light speed from different reference gauges. We do not even know the primordial light speed used to form the non-dimensional cosmological potential. Once potentials are made non-dimensional, the time rate of change must be calculated in the local reference time associated with the acceleration. Failure to make appropriate distinctions may result in exponential scaling terms in the acceleration equation that do not belong.

We saw when calculating trajectories in local space from cosmological changes, the dimensionless potential takes on the role of dimensionless time. For purpose of calculating accelerations locally it is a good practice to consider the instantaneous epoch of the trajectory in time and space should also be the reference for zero gravitational potential. Since potentials always have some normally arbitrary reference energy, this is permissible. We are only interested in changes in dimensionless potential. Whenever the dimensionless potential is differentiated, the zero base for the potential goes away, but we always end up with a light speed squared in the denominator to make potentials dimensionless. The local gravity potential must be made non-dimensional by dividing by light speed calculated locally with the same units of measure as the local gauge. The time rate of change must similarly be calculated for the local time reference for the trajectory.

For purposes of discussion and calculation it is useful to define three distinct light speeds as follows:

c_0 = Light speed of an empty primordial universe with zero potential;

c_n = Light speed now far from local gravitational bodies at present cosmological time;

c = Light speed in local space and time of body in motion.

Regarding the cosmological deceleration we have already discussed, it should be clear that there must be a universal frame of reference established when mass was created in the universe. The argument for this is clear. When particles consisting mostly of protons were created at the beginning of the universe, the particles had random velocities in all directions, i.e. no preferred direction. None of the particles had speeds greater than the then light speed of the previously empty universe. Since the random velocity distribution has uniform velocity densities in all directions, the average velocity is zero establishing a universal rest frame forever. The acceleration equation derived for the Pioneer cosmological effect causing deceleration proportional to velocity applies equally to either the universal reference frame or the local solar system frame, because the entire solar system or for that matter the galaxy motion with respect to the universal frame is decelerating. We can therefore focus on just the relative velocity with respect to the solar local frame of reference when determining the cosmological deceleration with respect to that body of reference.

We now predict additional previously un-modeled accelerations caused by motion in a local gravity gradient. We restrict for now our discussion to one local gravitational body of interest using our definitions of the various light speeds. We define the total non-dimensional gravitational potential to be used in exponential scaling terms in the Krogh theory including cosmological and local potentials as:

$$\phi = \frac{\Phi_u}{c_0^2} + \frac{\Phi_g}{c_n^2} = \phi_u + \phi_g\,, \tag{27}$$

where Φ_u is the potential of the observable universe, and Φ_g is the potential of the local gravitational body in both cases expressed in whatever units are used for the respective light speeds. We of course do not know c_0 but we know the time rate of change of that dimensionless term from the cosmology solution. To include the perturbing acceleration contribution of motion by transport through the gravity gradient, we must use the total time derivative of the dimensionless potential by adding the dot product of the velocity and the gravity gradient to the time derivative in (27). We can write the total perturbing anomalous acceleration from cosmological and gravity gradient contributions as:

$$a_p = 3v\,\frac{d\phi}{dt} = -3vH + \frac{3v}{c_n^2}\,(v \cdot \nabla\Phi_g)\,. \tag{28}$$

It is understood that the velocity is a vector. The first term on the right is the Pioneer anomaly cosmological acceleration term. The final term is added due to the requirement to use the total time derivative of the potential. Both terms contribute to anomalous accelerations for the Pioneer probes, but presumably the second becomes small when far from the Sun. A full treatment of the Pioneer anomaly needs to include this term especially for movement in the early stages in the inner solar system. The second term affects the orbits of planets or other bodies moving within the solar system. The later portion of the Pioneer trajectory far from the Sun would depend mostly on the first term cosmological effect and has so far been the only one considered.

5.2.1 Mercury orbit

We will now show that the second term on the right of (30) predicts the motion of planet Mercury identical with previous General Relativity predictions. If we restrict the discussions to just the Sun's gravity gradient for our purposes and ignore the small cosmological contribution of the first term, the perturbing acceleration can be written:

$$a_p = \frac{3v}{c_n^2}\,(v \cdot \nabla\Phi_s)\,. \tag{29}$$

Defining μ as GM_s for the Sun's gravity we know its radial gravity gradient and terms forming the scalar dot product with the velocity in (31). The perturbing acceleration in the direction of the velocity vector becomes:

$$a_p = \frac{3v}{c_n^2}\left(\frac{\mu}{r^2}\frac{dr}{dt}\right). \tag{30}$$

This acceleration caused by passage through the gravity gradient directed along the velocity vector is either positive or negative depending on the radial velocity direction. It will be immediately clear to those familiar with orbit maneuvers used to change argument of perigee for earth satellite orbits that pairs of accelerations in opposite directions before and after perigee will rotate the orbit ellipse. We need only to analyze the integrated effect of this perturbing acceleration to show that it duplicates the change predicted by GR. Note that no curvature of space is involved in the new gravity theory. The effect here is caused only by the conservation of instantaneous momentum in response to mass changes in the variable gravity potential along the orbit path as predicted by the new gravity theory.

A time-honored way to do this type of analysis is to use the Gauss planetary equations to calculate the cumulative integrated effect of small acceleration perturbations departing from normal Newtonian orbit mechanics. To use the Gauss planetary equations, we need components of perturbing accelerations in the radial and in plane tangential direction perpendicular to the radius. At this point we can dispense with the subscripts for light velocity since we can just use the light speed consistent with the location of the Mercury orbit. We begin by writing the components as:

$$a_r = \frac{3}{c^2}\,\frac{\mu}{r^2}\left(\frac{dr}{dt}\right)^2; \tag{31}$$

$$a_\theta = \frac{3}{c^2}\,\frac{\mu}{r}\,\frac{d\theta}{dt}\,\frac{dr}{dt}\,. \tag{32}$$

Before we can integrate the appropriate Gauss equation with substitution of these acceleration components, we need to express them only in terms of the orbit true anomaly θ because the integration will be over θ for one orbit revolution. We want both components written in terms of functions of θ times the time derivative of θ. We need the following orbit mechanics identities to make substitutions in terms:

$$r = \frac{a\,(1-e^2)}{1+e\cos\theta}\,; \tag{33}$$

$$\frac{dr}{dt} = \frac{r^2 e\sin\theta}{p}\,\frac{d\theta}{dt} = \sqrt{\frac{\mu}{p}}\,e\sin\theta\,; \tag{34}$$

$$\left(\frac{dr}{dt}\right)^2 = \sqrt{\frac{\mu}{p^3}}\,e\sin^2\theta\,\frac{d\theta}{dt}\,. \tag{35}$$

Using these orbit identities substituted for the appropriate terms for the perturbing accelerations to obtain the forms dependent only on true anomaly θ, we now have the alternative forms desired:

$$a_r = \frac{3}{c^2}\sqrt{\frac{\mu^3}{p^3}}\,e\sin^2\theta\,\frac{d\theta}{dt}\,; \tag{36}$$

$$a_\theta = \frac{3}{c^2}\sqrt{\frac{\mu^3}{p^3}}\,e\sin\theta(1+e\cos\theta)\,\frac{d\theta}{dt}\,. \tag{37}$$

The appropriate Gauss planetary equation expressing the time rate of change of argument of perihelion with radial and tangential perturbing accelerations is given as:

$$\frac{d\omega}{dt} = \frac{\sqrt{1-e^2}}{nea}\left[-a_r\cos\theta + \left(\frac{2+e\cos\theta}{1+e\cos\theta}\right)a_\theta\sin\theta\right]. \tag{38}$$

Substituting perturbing accelerations from (38) and (39) into (40) and replacing n and p with the relations:

$$n = \sqrt{\frac{\mu}{a^3}}\,; \tag{39}$$

$$p = a(1-e^2)\,, \tag{40}$$

$$\frac{d\omega}{dt} = \frac{3\mu}{c^2 a(1-e^2)}\left[-\sin^2\cos\theta + \sin^2(2+e\cos\theta)\right]\frac{d\theta}{dt}\,. \tag{41}$$

Integrating over one revolution for the change in argument of perihelion we have the result:

$$\Delta\omega = \frac{6\pi\mu}{c^2 a(1-e^2)}\,. \tag{42}$$

This is identical to the prediction from General Relativity and consistent with observations of the Mercury orbit. We show in this example testing our methodology of conservation of instantaneous momentum with changing mass dependent on gravitational potential along the path of the orbit, that our dynamic model is confirmed. This prediction is made without any need to require that space is curved. The motion is duplicated by accelerations along the velocity vector direction only.

5.2.2 JUNO orbit anomaly

The JUNO spacecraft has been orbiting Jupiter in a highly eccentric orbit. Because Jupiter is so massive and the spacecraft passes through strong gravity gradients near the planet with substantial radial velocity, it experiences similar anomalous accelerations as predicted in the previous section for Mercury's orbit around the Sun. We have already shown that our new dynamics model works for the Mercury orbit by replicating rotation of the orbit ellipse as observed and consistent with prior GR predictions. In the case of JUNO, we have an additional and unique opportunity to test our new theory and show that it is superior to GR since it predicts more than just the global observation that the ellipse rotates. The opportunity arises because we have precision doppler tracking data for the spacecraft which was not available for the planet. The perturbing accelerations produce velocity variations which should be directly observable with doppler tracking which are predicted by the new dynamics and not by GR. Anomalous unpredicted velocity variations have already been reported by Acedo *et al* [9].

Unfortunately, currently we have neither the data nor the resources to confirm that our new dynamics correctly models the JUNO discrepancies in observed trajectory. The fact that anomalies are predicted, exist, and are currently unexplained suggests that such test are clearly warranted. To do the work correctly will require careful attention to all the gravity models in the Jupiter environment including moons and the non-spherical planet models. We have provided a proposed model for the anomaly source which would have to be added to existing models by the appropriate investigators. We encourage that this effort take place.

5.2.3 Earth flyby anomalies

Several examples of Earth flyby velocity anomalies have been reported. Earth flybys are common practice for giving spacecraft a gravity-assisted boost to higher velocity primarily to reach the outer solar system or to exit the solar system such as for the Pioneer probes. The observed anomaly is generally described as a difference between the asymptotic velocity solution from Earth approach and Earth exit as reported by Acedo [10]. The effect causes an inability to fit the tracking data for the whole trajectory connecting both approach and exit. The anomaly varies substantially depending on the nature and geometry of the Earth gravity encounter.

The new dynamic model we have proposed here would obviously produce discrepancies of the type observed in Earth flybys. The effect is entirely based on the variation in mass of the spacecraft as it is in transit through the gravity potentials of all the bodies involved including Sun, Moon, and Earth. Since we require momentum to be conserved the velocity increases or decreases depending on whether gravity potential decreases or increases with respect to all gravitational bodies in play. We have shown how to model the perturbing unmodeled accelerations, which could be added to the tracking reduction fitting models in detail. We of course do not have the data or assets to do this but suggest it would be appropriate to make such a test.

Another simpler method is suggested as well just for purposes of explaining the cause of the anomaly. Since the gravitational accelerations from the bodies are well modeled already, and they are the only thing that can change the momentum along the trajectory of the spacecraft, we would have already accounted for momentum change from ordinary accelerations correctly. It would be instructive and perhaps sufficient to simply determine the total dimensionless gravity potential of all gravitational bodies at the positions of asymptotic Earth approach and the asymptotic Earth exit. From this we can calculate the difference in dimensionless potential between the two points in space comparing approach to exit points. Using the Krogh gravity theory, we can then calculate the predicted ratio of spacecraft masses between approach and exit by evaluating the exponential function with the difference in dimensionless potential in the exponent. The ratio of velocity at exit observed to expected should be the inverse of the predicted mass ratio. The prediction could be expressed by the relations:

$$\frac{V_a}{V_e} = \frac{M_e}{M_a} = e^{3\Delta\phi}\,; \tag{43}$$

$$V_a = V_e e^{3\Delta\phi}\,, \tag{44}$$

where V_a is the actual exit velocity and V_e is the expected exit velocity while $\Delta\phi$ is the difference in gravity potential divided by c^2. It is important that the spatial positions at both approach to Earth and exit asymptotes are actual best estimates. The integrated gravity accelerations must be over the actual trajectory between these points in space. This shortcut approach is suggested only as a simpler approximate method which has some possibility of success, but it does not replace integrating the correct instantaneous perturbing accelerations according to the dynamics model. To remove current errors in spacecraft navigation it will be necessary to include the corrections for the integrated accelerations to fit tracking data correctly and minimize residuals.

5.2.4 Pioneer outgoing transient

The Pioneer cosmological deceleration anomaly is discussed in §5.1.2. When the probe was sufficiently far from the Sun and solar system bodies, the continuous cosmological deceleration anomaly may be dominant, but it should be recognized that other perturbing accelerations were present and may at times be significant during the outgoing trajectory as the probe left the solar system. The model for modified dynamics caused by passage of a body through gravity gradients has been discussed in a prior section with the perturbing acceleration given by (31) where we proved the validity of the model for the orbit of planet Mercury. The Pioneer probes would experience anomalous accelerations near Earth flybys, passage near other planets, and particularly the entire escape from the Sun's gravity potential. During exit from the Sun's potential the effect will be an acceleration which would oppose the cosmological deceleration which is present continuously. Since the anomalous acceleration is also proportional to velocity, the effects would be more pronounced during periods of higher velocity, generally occurring in earlier phases before the deceleration from Sun escape slowed the probe. The acceleration would diminish with distance from the Sun both as the velocity slowed and the Sun's gravity gradient became weaker. The cosmological deceleration is abated only by the lower velocity far from the Sun so the presence of proportionately higher perturbing acceleration closer to the Sun would flatten the observed net perturbed deceleration. There is no intent here to analyze the trajectories in detail but to make the claim that these effects are predicted, and a model has been provided. The effects were not predicted by General Relativity but are direct consequences of the new gravity theory proposed by Krogh including the resulting cosmology solution provided here.

5.2.5 Cosmological orbit decay

An additional prediction of the proposed cosmology and the Krogh gravity theory is that all orbits will decay under the influence of the increasing cosmological potential and conservation of momentum with changing mass of the orbiting bodies. Cosmological deceleration occurs in any orbiting body like what was observed for the Pioneer probes. We will for simplicity consider circular orbits of a small mass around a much larger central body as in planetary orbits. Because the satellite body is in orbit, any small reduction in tangential velocity from a cosmological deceleration will result in a deficiency in the centripetal acceleration, causing the body to accelerate radially toward the central gravitational body. The resulting trajectory is a shallow nearly circular spiral continually reducing the orbit radius. In the process the angular momentum must be conserved as the radius decreases and the mass increases. Because there is a small radial velocity the intensity of the negative gravity potential increases further due to the reduction in radial distance to the central body. This gravity potential change is in addition to the cosmological change causing the orbit to decay an additional amount. For weak gravity gradients the additional amount is small while in the presence of very strong gravity gradients the orbit will become unstable with a steep spiral.

Consider then a small body spiraling toward a much more massive central body. We assume the orbit radius changes only a very small amount per revolution so that the velocity vector is considered perpendicular to the radius vector and equal to circular orbit velocity. With this assumption we can calculate the rate of decay of the orbit over a cosmological time interval with our cosmology providing the measure of the gravity potential change. We further include the potential change resulting from reduction of orbit radius in the gravity gradient, which provides a method of testing if a given example can be considered as a stable near circular weak gravity case. With our assumptions and the requirement that angular momentum is conserved as the mass of the orbiting body increases with changing potential, we can easily calculate the elapsed cosmological time required for any given reduction in orbit radius. Conservation of angular momentum requires:

$$m_0 v_0 r_0 = m v r\,; \tag{45}$$

$$\frac{m}{m_0} = \frac{v_0 r_0}{v r} = \sqrt{\frac{r_0}{r}} = e^{-3\Delta\phi}\,; \tag{46}$$

$$\frac{r_0}{r} = e^{-6\Delta\phi}\,, \tag{47}$$

where we have substituted for circular velocity at both radii and applied the Krogh gravity theory for scaling the change in orbital mass. Since GM remains constant at the times for both radii, it cancels out for the ratio of the starting and ending radii. The product GM will remain in the equation for total change in dimensionless potential $\Delta\phi$, which will affect our test for the weak gravity assumption for orbit stability. We can write the total change in dimensionless potential which applies to the exponential scaling of mass ratio as:

$$\Delta\phi = -Ht + \frac{GM}{r_0 c_0^2} - \frac{GM}{r c_0^2}\,, \tag{48}$$

where the time t is the time from the starting radius to the ending radius. Substituting this total potential change in the exponent of (49) and taking the natural logarithm of both sides:

$$\ln\frac{r_0}{r} = -6\Delta\phi = 6\left(Ht - \frac{GM}{r_0 c_0^2} + \frac{GM}{r c_0^2}\right). \tag{49}$$

Solving for transit time to go from the initial radius to the final one we have the result:

$$t = \frac{1}{H}\left[\frac{1}{6}\ln\frac{r_0}{r} - \left(\frac{GM}{r c_0^2} - \frac{GM}{r_0 c_0^2}\right)\right]. \tag{50}$$

For our assumption of near circular and stable orbits to be valid the difference in potentials in parenthesis must be small compared to the logarithmic term to its left in the brackets or otherwise stable near circular orbits cannot be sustained and the orbit will go into a steep spiral into the central body. This would be an example of very strong gravity fields resulting from either very large central mass or small orbit radius. For strong gravity fields a more complex integration of the dynamic model would be required to describe the trajectory. In the case of Earth orbit around the Sun at its present radius, the term on the right is many orders of magnitude smaller than the term on the left and can be neglected. An interesting conclusion for weak gravity fields is that the orbit radius decay is very similar to nuclear decay where it can be defined as a half-life. This is a direct result of the exponential relationship and the linear change in universal potential with time given by the applicable late term solution for our cosmology framework.

It is also important to consider that the solution obtained assumes that the central body GM is constant which is not strictly true for example if it is a star like our Sun. The Sun is losing mass from nuclear fusion and expulsion of solar wind particles. If we try to measure the distance to the Sun with the Earth diameter to measure parallax, we will have to understand that the Earth diameter is shrinking cosmologically which would mask some of the change in orbit diameter. The energy radiated by the Sun is also changing as well. According to the cosmology and the Krogh gravity theory the rest mass energy of the Sun is falling as the universal gravity potential is increasingly negative. Depending on what the net effect is, it is conceivable that global warming could be affected, but because changes occur so slowly it is unlikely to be significant.

5.2.6 Galaxy rotation and decay

Galaxy dynamics has long been a complex N-body problem difficult to model including unknown distribution of collective mass density from all the stars and other matter present. The present consensus theory includes the supposed existence of non-baryonic dark matter halos. It is not in the scope of this paper to develop necessary new galaxy simulation models that will be needed in the context of the new cosmology framework proposed. What is worthwhile is to point out how models developed with prior cosmology and gravity models are no longer valid in the new context. Prior observational methodologies are incorrect without knowledge provided by the new paradigm. The cosmological deceleration required by our solution becomes the same order of magnitude as the radial gravity gradient acceleration at large distances from galactic center, so dynamics cannot be understood without these terms.

We have just discussed in the prior section how orbits are subject to cosmological decay as the universal potential becomes increasingly negative because of continuous arrival of gravity from the most distant mass density just arriving since matter was created. Entire galaxies are also subject to this decay with the difference that galaxies rotate very slowly and have enormous size. Because the time for even one rotation is so large, the notion of circular orbits around the galaxy center is inherently flawed since conservation of angular momentum of the galaxy contents will cause the entire content of the galaxy to decay toward the center as the mass of these contents is forever increasing with the cosmological potential change. Since a black hole normally will exist at the center, the dynamics of the new framework will continually feed the galaxy contents into the black hole. Unless a galaxy continues to create new stars from infalling interstellar matter, it will be destined with sufficient time to turn into a supermassive black hole and no longer exist as visible matter. We showed that as orbiting matter gets closer to a massive center with very strong gravity gradients, it will become unstable causing it to spiral more rapidly and become consumed by an existing black hole.

Because of slow rotation and size, near circular orbits cannot exist inside galaxies at all, because cosmological dynamics will dominate the motion. Newtonian dynamics cannot describe their motion correctly. It can be said that galaxies are accretion disks around a black hole center. Since we already know galaxies no longer producing stars are common, we can expect that some galaxies may have already been consumed by supermassive black holes or at least their stars have since gone dead. These would contribute to dark baryonic matter throughout the universe. Galaxy clusters may have more dead galaxies than visible ones. Since atomic time moved more rapidly in the past, we can expect that stars would not have lived as long then.

Returning to live observable star producing galaxies we know that such galaxies have infalling interstellar matter continually producing those stars. With our new dynamics, the age of the visible stars says little about the age of the galaxy because oldest stars would have spiraled into and been consumed by the massive center black hole. A better indicator of galaxy age is the mass of the central black hole which requires time to produce and continually grows. Considering what we now claim about galaxy dynamics, the notion that galaxy rotation curves can be observed by assuming stars are in circular orbit around galaxy centers and the redshifts of stars can be used as a measure of orbital velocity is fundamentally flawed. The Hubble space telescope has had sufficient time and resolution to track the actual motion of stars in the Small Magellanic Cloud, a satellite galaxy of the Milky Way. NASA [11] found a pronounced inward spiral flow of stars towards the center which is consistent with what we propose to be the normal galaxy dynamics expected.

Expecting spiral motion is the norm, it is incorrect to assume stars are in circular orbits about galaxy centers when projecting line of sight doppler measurements. Since stars moving at higher velocity have higher cosmological deceleration from changing mass, effects are pronounced. Velocities near escape are expected for infalling interstellar gas sufficiently far from galaxy centers. Even stars which are measured to have velocity higher than escape velocity after formation will still be captured by the galaxy potential due to cosmological deceleration. The diameter of galaxies is so large that it takes considerable time just to pass by, so the cosmological effects are far more pronounced than for smaller planetary orbits. Integration of a free coast trajectory of a mass initially at escape velocity results in deceleration to circular velocity from cosmological increase of gravity potential predicted in about 1.6 billion years, a time comparable to galaxy rotation period in the outer extremes of the galaxies.

Because of this new cosmological capture process, there is a transition region which applies to galaxies in their outermost regions. These regions consist of infalling matter and stars which remain initially near Newtonian escape velocity or higher. The escape-like infalling outer region transitions to a quasi-circular stable body of the galaxy in the mid regions. It is never circular but will have a near circular tangential component of velocity, which has been misinterpreted by incorrect doppler projection. Because the infalling matter has inherent rotation with respect to the galaxy center, we know that as infalling stars decrease their radius the tangential rotation component of velocity will increase to conserve angular momentum. The cosmological deceleration from the potential change will act to reduce the velocity vector magnitude as it acts in the direction of the velocity vector. At the same time, the tangential component of velocity affecting the line-of-sight doppler measurements increases to conserve angular momentum, so the combination results in a near constant tangential component with radius observed in the doppler as interpreted. The spiral motion winds up as the radius decreases and the spiral flattens out. When the radius is small enough, the path becomes quasi circular regarding the tangential component like the inner galaxy region. The assumption of circular orbit has misled us to believe Newtonian dynamics is in play in the interior while something else controls the outer extremes of the galaxy. This led to either the MOND or dark matter halo incorrect conjectures.

We claim that a transition capture process is the MOND effect. There is no change in Newtonian gravity acceleration as supposed in the MOND interpretation. The problem occurs because doppler redshift distribution maps assume that line of sight doppler shifts come from circular velocities tangent to orbit rings centered on the galaxy center. Instead, what we have are spiral arm-like paths which begin steep in the outermost regions and are wound up tighter and flatter as the spirals approach the quasi-circular inner region. What it reflects is a capture process where the infalling matter is slowed cosmologically and captured by the galaxy. We believe that simulations of the transition region with dynamics we propose will result in apparent motion like MOND empirical interpretations of galaxy rotation based on the incorrect circular orbit projection assumption. We now have direct observational evidence of galaxy spiral star motion from NASA [11] proving this assumption incorrect. Since the speed of light is not constant, additional care should also be taken in measuring velocity from doppler redshifts.

5.2.7 Cosmological replacement for MOND

Based on the foregoing discussion we claim that the MOND galaxy dynamics conjecture is explained in its entirety by the dynamics and cosmology of our proposed framework. It should be recognized that we do not require dark matter to obtain the correct observed velocity rotation curves. This will occur naturally by updating future dynamics models with the perturbing accelerations required by Krogh gravity and our cosmology solution. Our objective here is only to provide the required framework, while we presently lack the computer models required to fully implement necessary changes. Instead, we apply conservation of angular momentum alone as we did in §5.2.5 for near circular orbit decay to the dynamics of galaxy capture of infalling matter beginning near escape velocity and spiraling into quasi circular orbit at capture. Quasi circular is defined here to mean that the tangential component of spiral motion equals circular orbit velocity normally expected with Newtonian gravity. We show that this occurs at what would formerly be interpreted as the MOND radius where the centripetal acceleration became consistent with Newtonian gravity potential of the galaxy. This is the region where flat galaxy rotation velocities are observed which led to the MOND conjecture for modified gravity. We can make significant conclusions and replace the MOND conjecture entirely by using conservation of angular momentum in the new framework. We assume a flat tangential velocity curve in the outer galaxy capture region and consider the transition to quasi circular tangential velocity. This is a special but representative case of a capture scenario which enables a simple solution consistent with observed rotation curves.

We must first correct the law of conservation of angular momentum in the variable mass context of the cosmology. We require conservation of angular momentum at different times where mass depends on the changing cosmological potential in accord with our solution. The angular momentum is taken with respect to rotation with respect to the galaxy center in question and applies to all interstellar mass engaged in free fall into a single isolated galaxy. Since the galaxy is an accretion disk, the size of the galaxy is all the mass inside the radius of some arbitrary mass such as a star in motion just outside of this radius. The effect of gravity is an acceleration vector toward the galaxy center in the radial direction. The tangential component of velocity provides an opposing centripetal acceleration in the radial direction, and we also have deceleration along the negative radial velocity vector required by the cosmology and confirmed by Pioneer probes. Cosmological deceleration occurs for both radial and tangential velocity components. There is a decay of angular momentum with respect to unit mass caused by cosmological mass change. Angular momentum of cosmological origin is the source of galaxy rotation and radial motion changes the tangential velocity component of any incoming mass. The radial acceleration depends on gravity acceleration, centripetal acceleration, and cosmological deceleration. Both mass change and radial motion dictates the tangential component of velocity by conservation of angular momentum. Angular momentum conservation for infalling masses requires:

$$v_t r m = v_{0t} r_0 m_0 \,. \tag{51}$$

Mass change from the cosmologically dependent gravity potential depends only on the Hubble constant which requires:

$$\frac{m_0}{m} = e^{-3Ht} \,. \tag{52}$$

Accounting for mass ratio dependence on cosmological time and substituting above we have a new general theory of angular momentum conservation that requires a time dependency of angular momentum per unit mass in the form:

$$v_t r = v_{0t} r_0 e^{-3Ht} \,. \tag{53}$$

We can now show that our conservation of angular momentum equation can be used to define the conditions which allow a flat tangential velocity to exist with respect to radius in an infalling region just prior to transition to a quasi-circular tangential velocity at radii below this transition. It is this region which previously has resulted in either the MOND interpretation of dynamics or the dark matter conjectures. Based on the actual observation of galaxies where this has been observed by projection of line-of-sight doppler measurements, we impose the existence of such a region at least as a potential scenario in such a transitional region. Differentiating (55) angular momentum conservation requirement with respect to time:

$$r\,\frac{dv_t}{dt} + v_t\,\frac{dr}{dt} = -3Hv_{0t}\, r_0\, e^{-3Ht} \,. \tag{54}$$

Substituting from (55) this becomes:

$$r\,\frac{dv_t}{dt} + v_t\,\frac{dr}{dt} = -3Hv_t r \,. \tag{55}$$

Solving for the rate of change of tangential velocity we have:

$$\frac{dv_t}{dt} = v_t\left(-3H - \frac{1}{r}\,\frac{dr}{dt}\right) . \tag{56}$$

To require a flat tangential velocity during some transition region we require that this derivative vanishes. This can be satisfied if:

$$\frac{dr}{dt} = -3Hr \,. \tag{57}$$

We also derive the radial acceleration required for acceleration balancing which by differentiation and substitution can be written:

$$\frac{d^2r}{dt^2} = -3H\,\frac{dr}{dt} = 9H^2 r \,. \tag{58}$$

We can also express the time dependence of the radius in the transition region from the differential of the natural log implied by (59) as:

$$r = r_0\, e^{-3Ht} \,. \tag{59}$$

We have thus determined by conservation of angular momentum alone in the context of the new cosmology framework how the radial velocity component must vary in some transition region at the exterior region of a galaxy where we presume the tangential velocity is flat with respect to time and therefore with radius as infalling matter is captured by the galaxy from interstellar space. The matter is falling in spiral motion with both radial and tangential velocity and we need to find how it occurs that the tangential component becomes equal to the velocity of a Newtonian circular orbit. It is this condition which has been erroneously interpreted to mean that the motion is circular in the interior of the galaxy. Due to the appearance of the Hubble constant, we see that the motion in the transition region formerly thought to be the MOND region has a cosmological origin which cannot be determined without our cosmology solution.

To define how transition to quasi-circular tangential velocity occurs where the dependence on radius is no longer flat, we must investigate what the radial equation of motion requires for the balance of centripetal acceleration with the negative gravitational acceleration. We no longer have the Newtonian equation alone because the descending radial component of velocity in the region is subject to the cosmological deceleration, the same as we found for the Pioneer anomaly. This deceleration is $-3Hv$ which is the same as the result given by (60). We require the sum of the cosmological deceleration of the radial velocity plus centripetal acceleration minus gravitational acceleration must equal the net deceleration given by (60). We can write the equation balancing radial accelerations as:

$$-3H\,\frac{dr}{dt} + \frac{v_t^2}{r} - \frac{GM}{r^2} = -3H\,\frac{dr}{dt} \,. \tag{60}$$

The far-left term of this acceleration equation is the cosmological deceleration of the radial velocity. The right-hand term is the total radial acceleration which must be the same as we have just required for the flat tangential velocity curve derived from conservation of angular momentum. The far left and right terms are equal and cancel out of the radial acceleration balance. The center two terms are apposing centripetal acceleration and gravitational downward acceleration which must also cancel each other because we require that the radius chosen will be the one that satisfies this condition simultaneously with what we required for radial velocity just before the transition. We can substitute the radius in terms of radial velocity from (59) as:

$$r = -\frac{dr/dt}{3H}\,. \tag{61}$$

Since the center two terms must sum to zero for the circular tangential component velocity requirement, we require:

$$v_t^2 = \frac{GM}{r}\,. \tag{62}$$

Using the radius required by (63) in (64) we must have:

$$v_t^2 = \frac{3HGM}{-dr/dt}\,. \tag{63}$$

We can satisfy this requirement if we require the negative radial velocity is the same magnitude as the tangential component so that the flat tangential transit velocity equals to circular velocity at the transition point. The sum of the two components results in a total velocity equal to Newtonian escape velocity. The flight path angle of the spiral path would be 45 degrees at transition to quasi circular tangential velocity. The tangential velocity required which satisfies the requirement for our assumed flat velocity curve scenario is given by the relationship between velocity and galaxy mass:

$$v_\infty = (3HGM)^{\frac{1}{3}}\,. \tag{64}$$

We can also write the relationship for the radius where the transition to quasi circular spiral motion occurs as:

$$r_m = \left(\frac{GM}{9H^2}\right)^{\frac{1}{3}}\,. \tag{65}$$

where we now use subscripts for the tangential flat velocity value and the transition to quasi circular Newtonian velocity to be consistent with the conventional terms used for the past MOND conjecture. Note that the relations are similar but not identical to those obtained for MOND. We do not require the transition to a minimum acceleration constant of the universe as required by MOND but instead have only the Hubble constant because the effect can be explained in total by the cosmology proposed. The scenario we used in the derivation is only strictly valid for a truly flat velocity curve in the external transition zone formerly representing the onset of MOND dynamics. We also do not have actual circular orbits anywhere in the entire galaxy. The galaxies have spiral flow everywhere and the motion cannot be understood without the proposed cosmology. Motion is not defined by Newtonian or GR dynamics, but only by the modified dynamics introduced here. This conclusion is supported by evidence reported by NASA [11] where actual tracking of stars in a small galaxy by Hubble Space Telescope resolved the actual spiral path of individual stars.

We found in our discussion of circular orbit decay that the radial apparent orbit exponential decay with time is at twice the rate prior to the MOND-like transition to quasi circular behavior, so there is a higher negative radial velocity after the transition occurs. The decay internal to the galaxy is only influenced by mass of the galaxy internal to the radius of the tangential velocity in question, so the velocity curves act in accord with Newtonian assumptions, but it is important to recognize the radial component of the internal spiral motion because it feeds the entire galaxy into its center. Another observation of the proposed dynamics is that we can explain the existence of relatively rare observed ring galaxies. A ring will occur if a galaxy experiences a prolonged period without being able to capture interstellar gas outside the galaxy. During such a period the galaxy radius shrinks toward the center with the spiral inflow. If interstellar gas capture inflow then resumes much later, new star formation will occur at the former radius dictated by the galaxy mass inside and a now isolated ring can form well outside of the now much smaller disk of the galaxy after star formation and gas capture had ceased. Normally when galaxies are continually producing stars, the galaxy will grow from the outside and accrete toward the center.

5.2.8 Black hole formation accretion and growth

In §5.2.5, we found that circular orbits about massive bodies in strong gravity gradients cannot exist since they are subject to being triggered into a spiral inflow path by even the small cosmological deceleration inherent to our new cosmology solution. The resulting decay of the orbit causes a runaway mass increase in a strong gravity gradient such that conservation of angular momentum will not allow high enough velocity to sustain the necessary centripetal acceleration for orbit. So, we have a situation where cosmological decay of orbit radius ensures that any orbit will ultimately reach a critical radius ending in spiral inflow into a black hole. There is thus a dynamic mechanism that assures accretion and growth of center black holes in galaxies with a supply of low radius stars or gas. Furthermore, the cosmological decay of all orbits ensures that orbiting material is doomed to reach that critical orbit radius with sufficient cosmological time. The age of stars in a visible galaxy is limited because supermassive black hole growth is a natural evolution of galaxies. Accretion of material into a black hole is much more efficient than gravity wave radiation to deplete angular momentum even though this still occurs with the Krogh gravity theory. This explains why supermassive black holes have more than adequate time to form even in the earlier universe now seen by the James Webb Space Telescope.

5.2.9 Superluminal galactic jet acceleration

Several galaxies have been observed to have Active Galactic Nucleus (AGN) particle jets generally perpendicular to the galaxy disks and apparently having a source near the center where a massive black hole is present. Many of the observed jets extend to great distances from the galactic center and appear to continue to accelerate far from the center while achieving superluminal velocities more than light speed. Examples of such AGN galaxy jet observations are discussed extensively by Meyer *et al* [12]. Present theory does not provide a cause for why a stream of particles would accelerate in the process of escaping powerful gravity gradients associated with a concentrated massive black hole, much less that they would reach velocities exceeding the speed of light we know in the process. We will show here that this is a natural result of our new dynamics and the Krogh gravity theory resulting directly from conservation of relativistic momentum with decreasing particle mass as the potential changes. It is the most extreme example of the same cause we found for the Earth flyby anomaly upgraded to relativistic momentum and relativistic epoch velocity.

Krogh discusses how massive objects which, with GR theory would be black holes, are never quite black regardless of how massive they are, since a small amount of light and even particles can escape from the mass. See for example his paper, "Galactic Nuclei and Jets in Wave Gravity" [13]. With the description, atomic particles like electrons and protons still exist sustaining the mass of the object but as is required by the theory, the particle size has shrunk to allow a highly compact volume which is not a singularity. A small fraction of charged particles with sufficiently high relativistic velocity can escape directly from the central mass along magnetic field lines at poles north and south and generally perpendicular to the spinning galactic disk. An accretion disk is not required to supply the escaping particles.

We need now to extend our conservation of momentum equations to relativistic speeds for this specific case to explain the observed acceleration that drives the jets. We return now to (22) beginning by repeating it here only with a new definition of how it applies at the local epoch. The equation originally was written to show how velocity changes with universal potential for originally created particles at the matter epoch of the cosmology solution. We write it again as:

$$v = \frac{v_0\, e^{3\phi}}{\sqrt{1 - (v_0^2/c_0^2) + (v_0^2/c_0^2)\, e^{2\phi}}}\,. \tag{66}$$

This equation was derived by equating the relativistic momentum to different points in time where the potential had changed from the epoch where velocity was v_0 to a later time where dimensionless potential ϕ resulted in a mass change in accord with the exponential scaling law given by Krogh theory. In effect it is a coast trajectory which would apply to any time dependent potential change. The dimensionless potential becomes the time variable describing the motion. We want to apply this equation much like we did successfully for the Mercury orbit in the non-relativistic case where conservation of momentum provides a contribution to acceleration in addition to any other accelerations resulting from local gravitational bodies. We no longer have the luxury of selecting a local speed of light which is close enough to consider a constant for the trajectory as for the planet Mercury or an Earth flyby. For a galactic jet escaping from a black hole, the speed of light changes rapidly with motion in the strong gravity gradient and we need to define the dimensionless potential by dividing by light speed squared to apply our gravity theory. For this discussion, we only need to tease out the instantaneous acceleration model for any location and time chosen as the instantaneous epoch of the trajectory.

Consider then (68) as a means to account for how much velocity would change if relativistic momentum is conserved as mass increases for a particle escaping from a massive galactic center. The total acceleration would need to include the deceleration from the local gravity gradient toward the mass center while the conservation of momentum from (68) would account for the reduction in mass as the particle moves radially outward. In the equation, the dimensionless potential is assumed to be made non-dimensional by dividing by c_0^2 which is the light velocity at the instantaneous epoch where velocity is v_0. The dimensionless potential varies with radial outward movement where we are only interested in the incremental change in the gravity gradient from motion at radial velocity v_0. With this understanding, we differentiate (68) with respect to time to obtain the acceleration from momentum conservation only. The resulting complex equation can now be simplified with the consideration that we can choose the dimensionless potential to be zero at epoch where we are evaluating the acceleration. If we do that, all the terms with exponentials become unity and we tease out the instantaneous acceleration resulting from conservation of momentum alone which is given by the simple equation:

$$\frac{dv}{dt} = v_0 \left(3 - \frac{v_0^2}{c_0^2}\right) \frac{d\phi}{dt}\,. \tag{67}$$

We see that if the velocity ratio v_0^2/c_0^2 is negligible, the result is the same as the previous perturbing accelerations used. In the relativistic case the initial velocity becomes large so that this cannot be considered a small effect any longer. If we substitute for the derivative of the dimensionless potential the appropriate dot product of velocity with the gravity gradient, we have the result for momentum conservation with changing mass only:

$$\frac{dv}{dt} = \frac{v_0^2}{c_0^2} \left(3 - \frac{v_0^2}{c_0^2}\right) \nabla \Phi_g\,. \tag{68}$$

It is immediately clear from this result that the leading factors multiplied times the gravity gradient can result in an acceleration radially outward due to decreasing mass greater than unity with a sufficiently high relativistic initial velocity. This means that highly relativistic particles will have a net acceleration greater than the attractive acceleration toward the gravitational body. Particles moving at light speed have the greatest factor of two times the gravity gradient so the particles accelerate at the same rate we would normally expect them to fall towards the body with Newtonian gravity. When the central body is a black hole, the gravity gradient is very large, and the acceleration will be substantial.

We have explained why relativistic galactic jets accelerate but the question of apparent superluminal speeds needs further explanation. In accord with the Krogh gravity theory, the speed of light is near zero at a sufficiently massive body. Light speed increases as the radial distance from the body increases. We can do the same differentiation of the required change in light speed with the dimensionless potential with the result that light speed accelerates at the instantaneous rate:

$$\frac{dc}{dt} = 2c_0 \frac{d\phi}{dt} \,. \tag{69}$$

Again, substituting for the derivative of the dimensionless potential at some velocity v_0 we have the result for acceleration of light speed:

$$\frac{dc}{dt} = 2\left(\frac{v_0}{c_0}\right) \nabla \Phi_g \,. \tag{70}$$

Comparing factors in (70) and (72), we conclude that light speed accelerates faster than jet escaping particles for any velocity. Eq. (70) is the perturbing acceleration not including the gravity potential acceleration toward the black hole. There is no scenario where the accelerating particle can exceed light speed, which is what we should expect from special relativity. We thus have explained why the particles accelerate, but the observation of superluminal velocity is an illusion caused by the fact that the cosmology tells us that light speed in the past is greater than present. By squaring both sides of (9), we know from our cosmology solution that the light speed ratio from emission in the past compared to the present is given by:

$$\frac{c_e}{c_n} = (1+z)^2 \,. \tag{71}$$

We see for example that at a galaxy redshift of 1.5 the light speed at time of emission from a distant galaxy is 6.25 times current light speed. We therefore predict that a galactic particle jet that leaves the center at relativistic speeds and accelerates can be expected to appear superluminal when we are assuming the wrong light speed. This is a remarkable confirmation of our new cosmology framework. We saw previously the redshift itself requires a light speed increase contribution.

5.2.10 Source of cosmic rays

Galactic jet acceleration provides a continuous supply of relativistic particles in the universe. We now have from Krogh [13] that black holes are always capable of producing and leaking relativistic particles in the form of jets following magnetic field poles north and south. From our discussion of superluminal jet accelerations, which are observed from active galactic nuclei, we further have explained how these jets accelerate and remain relativistic through escape from the black hole center and for that matter from the galaxy as well. We also expect from our previous cosmology discussions that the universe is so old that dead galaxies which have run out of interstellar gas and in some cases may have been totally consumed by the black hole center are likely to exist and may even well exceed the number of active visible galaxies. According to arguments from Krogh [13], the jets are expected even in the absence of any accretion disk, so the jets should exist for isolated unobservable black holes throughout the universe. We know from (23) that relativistic particles that survive collisions will remain relativistic with conservation of momentum as the speed of light slows cosmologically. We can with these arguments claim a continuous source of cosmic ray particles is predicted in our cosmology framework.

6 Concluding discussions

We have shown a new cosmology framework which explains why distant galaxies are redshifted without universe expansion while not requiring tired light decay in transit. By direct integration of variable light speed as known from our solution of the gravity potential differential equation and Krogh gravity theory, we derive a new Hubble curve equation consistent with observed redshift versus distance. The exponential form of the equation for the redshift factor derived directly from the theory agrees exactly with the same equation derived empirically from observations and ruled inconsistent with consensus universe expansion.

Solution of the governing equation for the time dependent universal gravity potential implies a matter creation epoch boundary condition with a gravitational matter observational horizon expanding at the variable speed of light derived from our solution. The matter creation was necessarily hot if for no other reason that there could be no preferred reference frame. We can speculate that matter creation occurred from a vacuum phase change, although just as for the Big Bang, there can be no specific cause of origin which is common to any theory of origins. Cooling occurred from conservation of momentum as particle masses increase with increasing time dependent gravity potential. A CMB surface of last scattering began after cooling to recombination temperature occurred. The surface is uniform because the density to the matter gravitational horizon is averaged over distances in the trillions of light-years at today's speed. The primordial plasma was fully thermalized and mixed over many Hubble times before recombination temperature was reached.

Assuming 3 000 K recombination temperature, time since the CMB surface formed was approximately 49 billion current length years, corresponding to about 453 billion years atomic time. There has been more than sufficient time for massive mature galaxies and black holes to form as observed by JWST. In fact, from the theory the relation between the Hubble constant and average matter density requires that density is 4/3 of classical Big Bang critical density. The age since CMB formation and higher matter density suggests prolific star formation. It is likely that many stars and galaxies are long since dead and unobservable except for their gravity. There is no reason to require non-baryonic dark matter which has never been found to exist. We believe that observed galaxy rotation can be fully explained without non-baryonic dark matter using the proposed dynamics here replacing the MOND interpretation as well. Dark energy and associated expansion are not relevant or necessary to have a valid Hubble curve shape.

Primordial light speed remains an unknown order of magnitude higher than present which would be necessary due to the exponential scaling equation which it obeys according to the Krogh theory. The dimensionless exponent is in number of Hubble times. Cooling of the plasma would require many Hubble times to reach the assumed recombination temperature of the CMB. There has been about 3.5 Hubble times making up the 49 billion current years since recombination. Primordial light speed is not particularly important to the cosmology if it is sufficiently high, because it only affects how much time the universe existed only in the plasma state. It also scales the distance to the matter horizon and is the cause for smoothness of the CMB because of the enormous distances over which the matter density is averaged. It essentially replaces inflation in consensus cosmology without *ad hoc* assumptions.

The Hubble constant is the most important constant of the cosmology. This constant essentially defines the dimensionless Hubble times which are required as the independent variable for the cosmology solution equations. We know exactly from the theory how it can be determined from the average matter density of the universe, but that is not an observable quantity especially since most of the matter is invisible. Three methods come to mind as alternatives. The first is to develop the conventional distance ladder as in the past and try to find the Hubble constant that best fits the redshift versus distance. It would be necessary in this process to ensure that any analysis involved with processing the various types of data used such as standard candles removes any prior possibility of embedded assumptions of universe expansion with redshift. We also need to look at each type of observation that may be affected by the evolution of physical constants and atomic time with cosmological dimensionless potential. This could change the brightness of supposed standard candles at different cosmological times. We showed in Figure 4 that data previously obtained by others can be fit reasonably well with only a single Hubble constant as an unknown. We cannot say that the assumptions embedded in the old data are any longer correct in the new context. Development of the distance ladder revisions as necessary would be beyond the scope of our goal of providing only a new framework here. We caution that this method would best be done by investigators with custody of the raw data who would need to process that data with knowledge of the new context and gravity theory.

A second method which is entirely new is to measure the Hubble constant directly from observed cosmological deceleration, such as observed for the Pioneer probes. Unfortunately, the accelerations are small and can be contaminated by other small acceleration causes. We have already pointed out here that there are other small perturbing accelerations resulting from transit through local gravity potentials from any and all gravitational bodies. We do believe that the local potentials are well known and the trajectories of the probes as well so that it should be relatively easy to model these and subtract them out. The remaining non-cosmological contributors would still need to be removed as effectively as possible. We would encourage investigators to make such and effort with the goal of teasing out a Hubble constant from data that already exists. A better application of this new approach would be to design and launch a new probe tailored for this purpose alone. The probe should be launched at the highest velocity which can reasonably be obtained since the cosmological acceleration is proportional to velocity. It should include the best possible tracking technology for detecting the small anomalous acceleration and should be designed to minimize any external causes of acceleration. This may provide an alternative allowing direct measurement of the Hubble constant.

A third method might be to take another look at the CMB radiation structure we already have and see if we can deduce the Hubble constant from the CMB structure. We no longer have expansion in play if comparing past structure to present universe structure, and we need to know for sure what the recombination temperature was because it too could scale with the past cosmological potential. The temperature determines the redshift and redshift plus Hubble constant determines distance of the surface required to understand the scale of structure. Any modeling of acoustic oscillations would have to be reworked because the speed of both light and sound is different at CMB time. Speed of light is tied to the black body temperature ratio and speed of sound is tied to both temperature and scaled lower particle masses, so both speeds are much higher than we have now. If this method has any credibility it needs to be determined by experts in this area.

Since the entire cosmology framework proposed rests on adopted new Krogh gravity theory which replaces General Relativity, we have included discussions of numerous predictions for gravitational dynamics changes implied by use of the teachings of Krogh theory of gravity. Since the new theory no longer involves curvature of space as with GR, but rather is restricted to flat Euclidean space, it requires modeling of any accelerations not a part of Newtonian gravity dynamics formerly replaced by GR. It still must replace GR dynamics where previously successful, but we found other predictions not predicted by GR which strongly support the Krogh theory. Since the Krogh theory requires changes to physical constants with the dimensionless gravity potential and these include rest mass, rest energy, and light speed.

It is not a trivial matter to tease out what the accelerations should be especially in relativistic dynamics. Krogh has used a few different approaches with at least limited success. Because mass and rest energy change, the usual conservation assumptions are risky. In this paper we have taken the approach uniformly that the only reliably conserved entity is momentum. We use this approach alone to tease out non-Newtonian acceleration dynamics. We confirm the methodology by proving that resulting Mercury orbit dynamics are consistent with confirmed General Relativity predictions.

Using conservation of momentum as our only assumption, we develop predictions not predicted previously by GR, but which have testable observational information. These include Earth flybys, JUNO Jupiter orbiter, Pioneer Probe, apparent superluminal galactic jet acceleration, galaxy rotation and spiral flow, and more rapid formation of black holes through faster accretion. All have been observed but those in possession of the observational data and modeling tools needed for adequate testing of our theory do not have the benefit of our model changes required. Perhaps the most remarkable is superluminal galactic jets, since the cosmology itself predicts that this is possible for relativistic starting velocities because the speed of light is far higher at distant galaxies. We predict the mechanism of acceleration through momentum conservation, while the changing light speed that the cosmology requires explains and enables apparent superluminal velocities for distant galaxies.

We have further shown that galaxy dynamics cannot be explained in the Newtonian or GR context where near circular orbits are presumed to describe the motion. Instead, all masses in the galaxy structure are engaged in spiral flow paths such that the entire galaxy is an accretion disk flowing into the center black hole. The outer region can exhibit flat tangential velocity which we can fully explain as a transition capture cosmological process without requiring MOND or dark matter *ad hoc* assumptions. Ring galaxies can also be explained by an interruption of interstellar matter inflow for an extended period followed by a resumption forming a ring of new star formation.

If the Krogh gravity theory is accepted as it must for this cosmology to have merit, there are consequences beyond cosmology. Cosmology was the primary objective in this work. Besides replacing General Relativity, Krogh's theory has further consequences for quantum theory and particle physics. Energy no longer gravitates, so it cannot be a contributor to mass of particles. It may imply that the Higgs mechanism accounts for all the particle mass. It might suggest that the Higgs energy is an indicator of the universal gravity potential since the Krogh theory requires particle masses and rest energies to change with the gravity potential.There is no longer a cosmological constant problem. Energy does not gravitate so the vacuum energy can be very large without creating a problem. The theory requires that the gravity potential changes the quantum vacuum state including speed of light and virtual particles. Models have already been introduced as for example Marcei Urban *et al* [14] which show how virtual particles could change light speed. Since all particles shrink and have reduced rest energy per particle in accord with Krogh theory, this can require a higher virtual particle density which would be expected to slow light speed. The gradient of the potential may be tied to a gradient in particle density.

As a further speculation we can note that if gravity causes the vacuum state to change as proposed, then it is the vacuum state which causes the acceleration of gravity. It is an acceleration and not a force, like principles shared by General Relativity. If there are a greater number of smaller vacuum particles deeper into a gravity well, then the gravity gradient is related to the virtual particle density gradient. If the real particles of an immersed test body are annihilated by virtual vacuum antiparticles they would be replaced by real particles from the vacuum in a preferential direction toward the higher particle density gradient. It seems plausible that the entire body could have all its particles replaced in a preferred direction toward the density gradient, resulting in an apparent acceleration. There would be no force explaining why a body in free fall experiences weightlessness rather than acceleration inertial forces.

If this is the mechanism of gravity acceleration, and we had a means to change the local vacuum state artificially, we could produce antigravity and we could accelerate objects or even occupants without experiencing inertia forces even for high accelerations. Obviously, we don't know how to do that artificially now, but we can certainly speculate that this mechanism could arise from the Krogh approach to gravity as a change of the quantum vacuum state and it shows how his theory leads to quantum gravity. Without a force there would not seem to be a need to require a new particle like the graviton.

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This cosmology framework is based in its entirety on Kris Krogh gravity theory [1]. His quantum vacuum approach eliminates General Relativity's Big Bang expansion, the primary cause of our pending cosmology crisis. A preprint has previously been published [15].

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