Informativity Expressions for Dark Energy and Dark Matter

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Providing a straight-forward explanation of dark energy and dark matter using only the physical laws of nature as they are known today has proved difficult and allusive. Using the principles of Informativity, a model based on counts of the fundamental measures—length, time and mass—an understanding of the expansion of our universe is resolved. Several expressions—mass of the universe, Hubble's constant, age of the universe, rate of expansion—are presented that exemplify the approach and mathematical procedures. The postulates of Informativity change our understanding of length, suggesting that our current understanding of galactic measure is distorted.

I. INTRODUCTION

For a predominate number of years throughout the age of modern physics our understanding of the space-time fabric has remained unchanged. The rules of behavior within space-time and the nature of observation between frames of reference have not changed appreciably since the time of Newton, except for one notable contribution by Albert Einstein, the theory of relativity. It seems if we are to remain grounded in our search for understanding the space-time fabric where the greatest break-through is one based on geometric relationships, we might consider more models based on the idea of geometry. That is, if geometry can play such an important role in prescribing the laws of physics in the local frame, why would we stop seeking other ways geometric relationships affect and define our reality?

Informativity is a model of understanding that has taken that route and resolved several notable mysteries that for the most part others have stopped looking at or resolved as inconsequential science that should be ignored. One such centerpiece of disfavor regards Planck's units of measure, for the most part considered a mathematical convenience without physical significance. If we are to embrace Einstein's work on relativity as physically significant to understanding the physical laws that define our reality, it would bear our attention to resolve why certain mathematical conveniences such as Planck Units and pi crop up in modern physics so often. Informativity [1] has taken that effort on directly not only resolving that Planck Units are physically significant, but presenting expressions that describe quantum measurement data which to date lack explanation and understanding.

In this paper, we begin on top of the successes of Informativity and focus on the subject of dark energy and dark matter expanding on our understanding of the space-time fabric as a geometric stage that defines our reality. The focus of this paper is to first map out an understanding of the space-time fabric and then present expressions for each of these phenomenon as geometric expressions of the space-time fabric. With this we will also find that there is no need to introduce exotic models of the early universe, its birth or its life to date.

II. METHODS

A. Understanding space-time

Consider time a convenient measure with which to better understand length and mass. Given a second what is the maximum number of fundamental units of length or mass that may pass a reference in a second? As example, we might consider a count of l_f that light can traverse. We may ask the same of mass. The expressions for each are

$$l_f \,/\, t_f = 2.99792458\ 10^{8}\ \text{m/s}, \tag{1}$$

$$m_f \,/\, t_f = 4.0371111\ 10^{35}\ \text{kg/s}. \tag{2}$$

Equation (1) may be recognized as the number of meters traversed by light in a second. Equation (2) is the number of kilograms that may be traversed in a second. By implication, each also describe a maximum rate of change that may be observed. To express a count of l_f, m_f or t_f, we would take a total and divide by the respective unit measure.

$$n_L = 2.99792458\ 10^8 / l_f \ = 1.85492\ 10^{43}\ units/s \quad (3)$$

$$n_M = 4.0371111\ 10^{35} / m_f \ = 1.85492\ 10^{43}\ units/s \quad (4)$$

$$n_T = 1/t_f = 1.85492\ 10^{43}\ units/s. \quad (5)$$

O_1: Law of Maximum Change: The three measures share one count such that the count of each of the fundamental units of measure is the same for any confined system.

$$n_L = n_T = n_M \quad (6)$$

We may refer to this as the law of maximum change.

Expressions (3-5) are best understood as a limit constrained by a count of the fundamental units that may pass a point in one second. Where one may say that matter is constrained to traverse no more than $2.99792458\ 10^8$ meters per second (i.e. the speed of light), we should say that observation is constrained to no more than $1.85492\ 10^{43}$ units of measure per second. The comparison brings to our attention that change whether that change is in length, mass or time is constrained. This frequency is a universal maximum defining an upper relative relation where a target may have:

- a maximum speed of l_f/t_f
- a maximum mass of m_f/t_f
- a maximum frequency of $1/t_f$

The law of maximum change is best understood in the first example, the speed of light. An observer cannot observe a phenomenon with a changing relative position at a rate greater than the speed of light. The maximum change limitation applies to each measure in no lesser a way than our understanding of the speed of light.

While we are readily familiar with the limits of length and time frequency, mass is a less familiar boundary. A maximum mass frequency does not limit the mass of the universe, but it does limit the total mass that may be observed from a point in space-time. Likewise, it follows that if an observer cannot observe mass beyond the limit, then that observer is also not subject to the gravitational effects of that mass. For all purposes, mass in excess of the limitation does not exist in the universe that is known to an observer. But, other parts of the universe that may be visible to other observers, will be subject to the effects of matter within the sphere of that point of reference.

With these principles established, let us turn our attention to the gravitational constant where

$$G = \frac{Q_{Lf} r c^3}{\theta_{si}} = \frac{Q_{Lf} r_{Lf} l_f c^3}{\theta_{si}} = \frac{c^3 l_f}{2\theta_{si}} = \frac{c^3 t_f}{m_f} = \frac{l_f}{t_f}\frac{l_f}{t_f}\frac{l_f}{t_f}\frac{t_f}{m_f}\ \mathrm{m^3/kgs^2} \quad (7)$$

The expression exposes two maximums, the maximum rate of l_f with respect to t_f (Eq. 1) divided by the maximum rate of m_f with respect to t_f (Eq. 2). To better understand this expression, consider a cube with sides measured in l_f equal to the distance that light can travel in one second. We find that this cube contains a count of c^3 units of cubes each with sides equal to l_f. The cube provides a grid like understanding of space depicting the maximum length frequency that may be observed.

Next, consider m_f/t_f as a one dimensional value defining a count of mass units that may exist along the edge of the cube, the maximum mass frequency. Thus, dividing the cubic length frequency $(l_f/t_f)^3$ by the mass frequency m_f/t_f gives us the fixed relation of mass relative to an observer in space-time, in other words the most suited understanding of a gravitational field in space-time.

We may make two observations. Firstly, the expression denotes that the relation between length and mass is not linear. That is, the length frequency for an observer in space is diluted in proportion to the mass frequency.

Secondly, where G expresses the curvature of space-time we may resolve the speed of gravity, $s_{gravity}$ in two steps. First multiply G by the mass frequency. Then reduce space-time by dividing the cubic length frequency in two of the three dimensions, c^2, such that the linear speed of gravity is

$$s_{gravity} = G\frac{m_f}{t_f}\frac{1}{c^2} = c \text{ m/s.} \tag{8}$$

Some might argue that this is merely a means of resolving the speed of light. In some sense this is true, but not in the context of expressions regarding the relative relation between length, mass and time. In that context, we are asking, what is the maximum rate of change with respect to space of mass. To succeed in this endeavor, we must first factor out the mass frequency and then reduce space to a measure in one dimension. In this context, we find the rate of change for the phenomenon of gravity in space-time is c.

III. RESULTS

A. Hubble's Constant

Determining Hubble's Constant using the principles of Informativity follows from the point of view of the observer. Consider the relation between length, time and mass [1] where

$$l_f m_f = 2\theta_{si} t_f \,. \tag{9}$$

The expression may be expanded contingent upon two constraints. Where each unit of measure has a corresponding count of that unit, n_L units of length, n_T units of time and n_M units of mass, then

$$n_L l_f n_M m_f = 2\theta_{si} n_T t_f \tag{10}$$

is true so long as $n_L = n_T$, and $n_M = 1$. The expression applies to all finite systems. For example, where the system is the universe we may state that there exists a precise whole-unit count of l_f and t_f and that they are equal in value. As such, the passage of time must correspond to an increasing count of n_T equal to n_L.

With this understanding, the better description of the space-time fabric is not a process of stretching, but a geometric relation that corresponds to an increasing count of length measures. New units of l_f are being added to the system uniformly and in a discrete, incremental, whole-unit manner.

Counter-arguments to a system that does not abide by this process would present formidable paradoxes. For instance, a background independent relatively defined system where maximum counts of l_f and t_f were allowed to differ would violate our understanding of a maximum permitted speed. Any attempt to balance such a system with a variation in mass would violate our understanding of the conservation of energy. In a universe where both of these constraints are strongly supported, we conclude that the passage of time must correspond directly with increasing length, an expansion of the universe.

It follows that a background independent system that has aged by a time $A_u = n_T t_f$ must correspondingly expand by an equal count of l_f such that $l_f/t_f = c$. The expansion must occur at the rate c relative to each point in the space-time. The calculation provides a differing understanding of the expansion of the universe while presenting a straight-forward expression reflective of the laws of physics in the local frame.

$$H = \frac{c/1000 \;\; km/s}{13.799 \;\; by \frac{10^9 \, y}{by} \frac{365.25*24*3600 \;\; s}{y} c \frac{m}{s} \frac{mpc}{3.086 \; 10^{22} \, m}} = 70.865 \text{ km/s mpc} \quad (11)$$

Converting this to standard units, we may also present Hubble's constant as

$$H = \frac{70.865 \;\; km/s \; mpc}{3.086 \; 10^{19} \;\; km/mpc} = 2.296 \; 10^{-18} \text{ s}^{-1} \quad (12)$$

Where the general expression as applied to interstellar expansion is typically calculated using Hubble's law as expressed with $v = H_0 D$, we find that Hubble's law is constrained and prescribed by the system, the universe, where D represents the distance travelled by light ($v=c$) for a time equal to the age of the universe ($A_g = 13.799$ *billion light years*). Thus, the value for H_0 may be resolved mathematically for any moment in time as a necessary outcome of the preservation of the relation between l_f and t_f in equation (9).

We must also differentiate the expansion of the universe from the expansion of matter within the space-time fabric. There is no known correlation between the two. At this point, we can only determine that the space-time fabric expands in a precise and consistent manner and that the matter within rests within that fabric moving relatively by whatever means respective of its initial conditions.

B. Dark energy

Having resolved that the passage of time must correspond to an increasing expansion in length of the space-time fabric as described in (11), we may now substitute and group counts of the fundamental units with more familiar terms. First, multiply both sides of (9) by ($n_{TA} n_{TD} t_f^2$). Then regroup the terms and substitute where the universe's diameter is $D_u = n_{TD} t_f$ (billion light-years) and age is $A_u = n_{TA} t_f$ (billion years).

$$(n_{TA}n_{TD}t_f^2)l_f m_f = 2\theta_{si}t_f(n_{TA}n_{TD}t_f^2) \quad (13)$$

$$(n_{TD}t_f)m_f\left(\frac{n_{TA}t_f c}{n_{TD}t_f}\right) = 2\theta_{si}(n_{TA}t_f) \quad (14)$$

$$D_U m_f\left(\frac{A_U c}{D_U}\right) = 2\theta_{si}A_U \quad (15)$$

A single solution exists for each moment in time D_U and A_U, where $(A_U c/D_U)=1/m_f$ cancels m_f.

$$D_U = 2\theta_{si}A_U = 2*3.26239*13.799 = 90.035 \text{ bly} \quad (16)$$

$$m_f = \frac{D_U}{A_U c} = \frac{90.035}{13.799*299792458} = 2.1764\ 10^{-8}\ \text{kg} \quad (17)$$

Eq. (16) is the dark energy equation, most straight-forwardly describing the rate of expansion of the space-time fabric. Providing A_U gives us D_U, m_f and their relation. Current measurements for D_U and A_U are respectively 91 billion light-years and 13.799 +/- 0.021 billion years [2]. Thus, as the universe ages its diameter 'must' expand by a factor of $2\theta_{si}$. In 2011, formulations by Barrow and Douglas [3] comparing the cosmological constant and the age of the universe had been worked out predicting a constant relationship. In 2015, analysis of WMAP data by Gasanalizade and Hasanalizade [4] furthered our understanding confirming a constant correlation between the age of the universe and its expansion.

If we use Eq. (2) as an understanding of the maximum observable mass that may traverse a point in space-time and then multiple that by the age of the universe in seconds, we may resolve a maximum observable mass of

$$M_U = \frac{A_U m_f}{t_f} = \frac{13.799*\ 10^9 * 3.1536\ 10^7 * 2.17643\ 10^{-8}}{5.39106\ 10^{-44}} = 1.7568\ 10^{53}\,kg\ . \quad (18)$$

Where $A_u=n_{TA}t_f$ the expression may be reduced further such that

$$M_U = \frac{A_U m_f}{t_f} = \frac{n_{TA}t_f m_f}{t_f} = n_{TA}m_f = 1.7568\ 10^{53}\,kg\ . \quad (19)$$

Keep in mind that the result is a frequency limitation of the universe where $n_T=n_M=n_L$. We could just as well write that the maximum observable mass in the universe as $M_U=n_{MA}m_f=1.7568\ 10^{53}\ kg$. The expression limits observation to a maximum rate of change regardless of density or direction as prescribed by the law of maximum change. Where a maximum count of mass units n_M may be observed, the limit is not a function of mass density but a physical limitation to observation no different than has been thoroughly established between the measures of length and time, $l_f/t_f=c$. The expression may also be written in the more general form $M_U=A_U c^3/G$.

Informativity denotes that at any point in space-time the maximum observable mass may not exceed a rate of m_f/t_f kilograms per second and thus the maximum observable mass is $1.7568\ 10^{53}$ kilograms at this point in time. The relation also prescribes that the maximum observable mass is increasing with the passage of time. This is particularly interesting as it provides an inherent mechanism for a universe with increasing mass. Such a universe would find increasing gravitational pull from its farthest reaches and where matter density is evenly distributed then the gravitational pull on matter within the universe will increase over time. Importantly take note that we are speaking of the matter within the universe, not the expansion of the space-time fabric. The two effects independently contribute to what is observed.

By way of comparison in the physical record, the mass of the universe may be estimated by multiplying the volume of the universe by its critical density. We can calculate volume based on the maximum observable size of the universe, a precise value which may be resolved knowing only the age of the universe with Eq. (16).

$$V_U = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi (D_U / 2)^3 = \frac{4}{3}\pi (90.035\ 10^9 / 2)^3 = 3.2363\ 10^{80}\ \text{m}^3. \qquad (20)$$

And we may estimate the density of the universe by calculating the critical density ρ_c and then multiplying that by the percent of ordinary matter observed ρ_m. The critical density expression consists of four elements [5]: ordinary matter (4.8%), neutrinos (0.1%), dark matter (26.8%) and dark energy (68.3%). Although density is contingent on the spatial curvature of the universe, based on observations of the cosmic microwave background from the Wilkinson Microwave Anisotropy Probe, curvature is measured to be close to zero, supporting the conclusion that the matter density of the universe is close to the critical density times the visible matter. Where the critical density [6] is

$$\rho_c = \frac{3H_0^2}{8\pi G} = \frac{3(2.296\ 10^{-18})^2}{8\pi G} = 9.431\ 10^{-27}\ \text{kg/m}^3 \qquad (21)$$

then the matter density is 4.8% of this value such that

$$\rho_m = 0.048 * 9.431\ 10^{-27} = 4.5269\ 10^{-28}\ \text{kg/m}^3. \qquad (22)$$

And finally, the mass of the universe is

$$M_U = V_U \rho_m = 3.2363\ 10^{80} * 4.5269\ 10^{-28} = 1.4650\ 10^{53}\ \text{kg}. \qquad (23)$$

The value indicates a mass that is 19.6% less than the maximum observable mass. Once the maximum is reached, gravitational acceleration will cease reduced entirely to the expansion of the space-time fabric.

We may gain a greater understanding of expansion in reducing these expressions as carried out in Appendix A. The units of this expression are ρ_m kg/m^3, H_o 1/s, A_u s and θ_{si} kg m/s. While H is appropriately presented in terms of km/s mpc, to remain consistent with the units of the other values, Hubble's constant H is replaced by H_o such that H is divided by the number of kilometers in a mega parsec. Through a series of substitutions we may reduce several values leaving us with an expression having variables on the left and constants on the right such that

$$\rho_m H_o^2 A_U^2 = \frac{2}{\theta_{si}^3}. \tag{24}$$

Keep in mind there are important caveats to this exploration. Firstly, we began by multiplying the size of the universe by a fraction of the critical density. Using critical density as a basis of understanding is a model of approximation, two conjectures in one. The model assumes that critical density is a physical component of the space-time fabric. Then, that the percent of observable matter is a known value. Lastly, in this reduction we have made use of expressions specifically applicable to the space-time fabric which have been established as distinct from the expansion of matter within the space-time fabric. The resulting expression is a composite of substitutions from the dark energy effect and the motion of matter in the space-time fabric. Together, these assumptions have significant limitations and at best allow us a generalized approximation to the observational record.

That said, we can make some important observations that are applicable. For instance, we can note that the suspect approximations appear safely contained in the term ρ_m. $H_o^2 A_U^2$ remains an interesting partnership, the first a frequency representing expansion of the space-time fabric and the second an age, together canceling their units. We may readily note that with an increasing age of the universe, the product $\rho_m H_o^2$ must decrease. At first sight, it would appear that the expansion must decelerate, but the product provides no tendency in either direction. Lastly, it should be noted that the units of this expression do not balance, but that has no effect on the proper calculation of values at each step of the derivation in appendix A. Where each expression maintains a calculation of H_o^2, you will find that resolving the expressions will produce the same value for H_o^2 thus demonstrating that the expression is mathematically accurate.

C. Dark matter

In reflection of the formulations regarding dark energy Informativity offers an opportunity to understand the phenomenon dark matter. As described above, the magnitude of the expanding space-time fabric is decipherable from (16) where $2A_U$ represents the diameter of the universe, then θ_{si} represents the expansion factor along the radius. Using M/r^2 as a representative understanding of the mass that might exist in a typical galaxy, we may apply the space-time expansion factor to distance to resolve what mass we should find. Where M_l is the observed mass and M_o is the expected mass, then we would expect to see

$$M_l = \frac{M_o}{\theta_{si}^2} = \frac{100\%}{(3.26239)^2} = 9.39568\% \tag{25}$$

of the expected mass.

This is precisely what we do see. Naturally, if a galaxy appears larger than expected and at the same time we are aware of a geometric distortion with a magnitude of θ_{si} affecting distance measurement, it would not be unexpected to realize that the angle of incoming light is in fact accurate because the galaxy is closer than our understanding of distance measure suggests. This is not to say that galaxies are closer than they appear, only that there is a disconnect between our understanding of distance in the local frame in comparison to galactic measure. Observational studies suggest a total baryonic mass within galaxies of 12-15% of the amount needed to gravitationally bind their stars [7] complimenting a geometric distortion effect. When accounted for, there is no missing mass.

I. APPENDICES

Appendix A: Expansion of the Universe –Dark Energy

$$M_U = V_U \rho_m = \frac{4\pi (D_U/2)^3}{3} * \frac{3H_o^2 \rho_m}{8\pi G} \text{ kg} \tag{26}$$

$$H_o^2 = \frac{2GM_U}{\rho_m (D_U/2)^3} \text{ s}^{-2} \tag{27}$$

$$H_o^2 = \frac{2M_U}{\rho_m (D_U/2)^3} \frac{\hbar c^3}{4\theta_{si}^2} = \frac{M_U \hbar c^3}{2\rho_m (D_U/2)^3 \theta_{si}^2} \text{ s}^{-2} \tag{28}$$

$$H_o^2 = \frac{A_U m_f}{t_f} \frac{\hbar c^3}{2\rho_m (D_U/2)^3 \theta_{si}^2} = \frac{A_U m_f \hbar c^3}{2\rho_m (D_U/2)^3 \theta_{si}^2 t_f} \text{ s}^{-2} \tag{29}$$

$$H_o^2 = \frac{A_U m_f \hbar c^3}{2\rho_m (D_U/2)^3 \theta_{si}^2 t_f} = \frac{D_U}{2\theta_{si} c} \frac{m_f}{t_f} \frac{\hbar c^3}{2\rho_m (D_U/2)^3 \theta_{si}^2} = \frac{D_U m_f \hbar c^3}{4ct_f \rho_m (D_U/2)^3 \theta_{si}^3} \text{ s}^{-2} \tag{30}$$

$$H_o^2 = \frac{D_U m_f \hbar c^3}{4ct_f \rho_m (D_U/2)^3 \theta_{si}^3} = \frac{2m_f \hbar c^2}{t_f \rho_m D_U^2 \theta_{si}^3} \text{ s}^{-2} \tag{31}$$

$$H_o^2 = \frac{2m_f \hbar c^2}{t_f \rho_m D_U^2 \theta_{si}^3} = \frac{2m_f (2\theta_{si} l_f) c^2}{t_f \rho_m D_U^2 \theta_{si}^3} = \frac{4m_f c^3}{\rho_m D_U^2 \theta_{si}^2} \text{ s}^{-2} \tag{32}$$

$$H_o^2 = \frac{4m_f c^3}{\rho_m D_U^2 \theta_{si}^2} = \frac{4m_f c}{\rho_m D_U^2} \frac{c^2}{\theta_{si}^2} = \frac{4m_f c}{\rho_m D_U^2} \frac{4}{m_f^2} = \frac{16c}{\rho_m m_f D_U^2} \text{ s}^{-2} \tag{33}$$

$$H_o^2 = \frac{16c}{\rho_m m_f D_U^2} = \frac{16c}{\rho_m m_f (2A_U c)^2} = \frac{4}{\rho_m m_f A_U^2 c} \text{ s}^{-2} \tag{34}$$

$$H_o^2 = \frac{4}{\rho_m m_f \theta_{si}^2 A_U^2 c} = \frac{4}{\rho_m (2\theta_{si}/c) \theta_{si}^2 A_U^2 c} = \frac{2}{\rho_m \theta_{si}^3 A_U^2} \text{ s}^{-2} \tag{35}$$

$$\rho_m H_o^2 A_U^2 = \frac{2}{\theta_{si}^3} \tag{36}$$

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