

Expansion Rate and Hubble Tension Study

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Abstract

Two methods of measuring Hubble's expansion rate constant H_0 that do not agree are called the Hubble tension. The WMAP and PLANCK mission results were $H_0 = 67.5 \pm 2$ km/sec/mpsec. Their methodology involved interpretation of the Cosmic Microwave Background using the Lambda Cold Dark Matter (LCDM) expansion model and the Friedmann equation. A higher value, $H_0 = 70.39$ km/sec/mpsec was recently reported from James Webb Space Telescope (JWST) observations. Using distances for luminosity events (Cepheid variables and longer-range Type Ia supernove) yields higher values. Measurements are accurate to several sigma, indicating that something fundamental may be occurring. The present study addresses the expansion rate. A new expansion model, called the straight-line model, allows H_0 to be determined in a straight-forward manner. The result is 73.291 ± 0.008 . Fundamental differences between the LCDM expansion model and the new model are reviewed. For example, derivations show that the concept of critical density does not apply to straight-line expansion. The continued motivation of this work is to understand the role of information in nature. The author believes there are two levels to nature: 1) an information level, 2) a correlated energy level. This belief is based on data that leads to an information-based proton mass model.

Keywords

Cosmology, Expansion, Hubble Constant, WMAP, PLANCK, Astrophysics, Black Holes

1. Background

Hubble tension is one of several concerning observations. Recent JWST observations show fully formed galaxies only a few million years after the beginning. Cosmologists believe that there was an early brief period of expansion called inflation, but also say that physics breaks down at a singularity. Inflation should keep different areas uniform, but new maps show huge voids and non-uniformities. Also,

observed primordial black holes and “red dots” do not fit current theories. WMAP predicts percentages of matter, dark matter, and dark energy that have not been confirmed.

1.1. Neutron and Proton Mass Simulations from Reference [1]

Mass models of the proton and neutron described in [1] are included for reference below in **Table 1**. Energy values for neutron and proton components are arranged into columns in **Table 1**. The simulated masses of the neutron and proton are marked in red below (accuracy vs. PDG data is shown). The models include an initial neutron expansion kinetic energy of 10.15 MeV and a potential energy of 10.15 MeV. The energy of 10.15 MeV/nucleon is also fundamental to atomic fusion. The neutron decays to a proton, electron, and anti-electron neutrino, and its mass and fields are listed along with the decay products toward the bottom right side of **Table 1**.

Table 1. Neutron and proton mass simulations.

MeV	MEV		MEV		MeV		MeV
m w/o ke	Neutron Mass Components		Neutron Fields		Proton Mass Components		Proton Fields
m	101.947	Mass	753.291	Strong Field E	101.947	Mass	753.291
m	13.797	Mass	101.947	Strong Field E	13.797	Mass	101.947
m	13.797	Mass	101.947	Strong Field E	13.797	Mass	101.947
	5.076	Ke	2.801	Gravitational Field	5.076	Ke	2.8011
	646.955	Difference KE			646.955	Difference KE	
	83.761	Difference KE			83.761	Difference KE	
	83.761	Difference KE			83.761	Difference KE	
	10.151	Fusion KE			10.151	Fusion KE	
	−20.303	Weak Field E			−20.303	Weak Field E	
m	0.622	(1.293 = 0.622+0.671)			−0.671		
130.163							
			−0.118		−5.44E−05	Em Field +1	−0.118
939.5654133	939.56541	Neutron Mass		938.2720814	938.27209		
Accuracy vs. PDG				Accuracy vs. PDG	2.72E−05	EM Field −1	
−7.2E−09				−9.59E−06	0.511	Electron	
					0.671	0.622 + 0.048	
					0.11141	Kinetic E	
					0.04850	ae neutrino	
	10.151	KE Expansion			10.103	KE Expansion	
	10.151	PE Expansion			10.151	PE Expansion	
	959.8680		959.8680		959.868		959.8680

The models contain values useful for a cosmology expansion model described in Topic 3. Specifically, the gravitational field energy is 2.801 MeV (upper right side of columns 2 and 4), and the initial expansion potential and kinetic energy are 10.15 MeV/proton, shown at the bottom of the tables. The models are based on information values labeled N that are correlated with energy. Probabilities for individual components are $p = 1/\exp(N)$. Multiplying the probabilities for all energy and field components, probability $p = 1/\exp(180)$ can be assigned to an individual proton. Since many are known to exist, a probabilistic argument can be made that, to restore unity, there were $\exp(180)$ neutrons in nature, most of which are now protons. There is also a particle on the left side of the table that consists of mass without kinetic energy. Its mass is 130.163 MeV and will be treated as dark matter.

Two previous studies conducted using the above values were reported. They are entitled “Structure formation study” [2] and “Galaxy formation study” [3]. Each presented promising results.

1.2. Model of Time and Space

Energy $E = h\nu$ is energy and frequency $\nu = 1/\text{time}$ are fundamental. This is also written $r = hC/E$ where h = Planck’s constant $H/(2\pi) = 4.136\text{e-}21/(2\pi)$. The value $hC = 1.97\text{e-}13$ MeV-m.

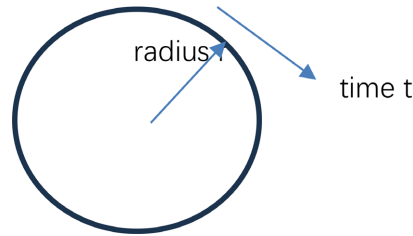


Figure 1. Space and time model.

Table 1 provides the gravitational field energy $E = 3 \times 0.687 + 0.740 = 2.801$ MeV. **Figure 1** shows the radius r and time t around the circle at velocity C below.

$$r = 1.93\text{e-}13/2.801 = 7.045\text{e-}14 \text{ meters.} \quad (1)$$

$$\text{time} = 7.045\text{e-}14 \times 2\pi/3e8 = 1.47\text{e-}14 \text{ seconds.} \quad (2)$$

1.3. Expansion Radius and Kinetic Energy

Inertial force F is proportional to velocity²/radius and velocity² is proportional to kinetic energy (ke).

$F = mv^2/r_0 = mV^2/r$, $v^2/V^2 = r_0/r$, $ke/KE = R/r$ With initial radius $r_0 = 7.045\text{e-}14$ m and initial $ke = 10.15$ MeV/proton, the radius r increases as ke decreases.

$$r = 10.15 \times 7.045\text{e-}14/ke \quad (3)$$

2. Straight-Line Expansion Model

Standard cosmology uses the Friedmann equations to describe the expansion of

the universe. They are based on Einstein's general relativity, the Friedmann-Le-maitre-Robertson-Walker metric, and the assumption of a perfect fluid. Expansion is driven by matter density and kinetic energy. As expansion occurs, kinetic energy is converted to potential energy. The WMAP and PLANCK missions incorporated these assumptions into the Lambda Cold Dark Matter expansion model to interpret data from the cosmic background radiation.

A straight-line expansion model was developed that does not use the assumption that expansion is driven by a fluid. Instead, it indicates that space is based on the velocity C . As shown in **Figure 1**, the radius determined by field energy = 2.801 MeV. This radius represents a sphere and is called a cell. The probabilistic nature of the proton model suggests that **Figure 1** is duplicated $\exp(180)$ times. In three dimensions, large R is scaled to $\exp(60)$ cells.

$$\text{Radius axis of expansion model } R = r \times \exp(60) \quad (4)$$

The radius R expands at the speed of light, and the universe expands with the advance of time.

$$\begin{aligned} \text{Time axis of expansion model} &= 7.045e-14 / (2\pi C) * \exp(N) \\ &= 1.476e-21 / (2\pi) * \exp(N) \text{ seconds} \end{aligned} \quad (5)$$

A framework based on C and duplication of surface velocity C cells is everywhere the same. The slope of large R vs. expansion time is a velocity C straight line. There is one proton placed on the surface of each cell. From the proton model (**Table 1**), each proton initially has 10.15 MeV of potential energy and 10.15 MeV of kinetic energy (ke). The velocity associated with 10.15 MeV is sub-luminal. Their velocity is tangential to the cell surface.

2.1. Proof That Gravity Does Not Resist Expansion

It was stated above without proof that expansion is driven by time. This is novel because expansion has been treated as a fluid density with kinetic energy that resists gravity. Understanding the forces on a proton on the surface of an expanding cell requires reviewing recent work on gravitation.

2.2. Dark Matter

The true mass of the three quarks in the proton model in topic 3 totals 129.54 MeV. But the quarks have kinetic energy, and the total proton mass = 938.27 MeV. The equations developed below use a particle without kinetic energy with mass 130.163 MeV from **Table 1**. According to Jean's theory [wiki], a particle without kinetic energy cannot develop pressure that normally resists gravitational accumulation. The name dark is appropriate because it forms early black holes that do not light up with fusion like normal matter. The particle was studied and shown to contribute to our understanding of cosmology in [2] [3].

2.3. Gravitation

A derivation for the gravitational constant G was presented in Reference [1]. Ex-

cerpts are repeated below.

From Equation (1), $r = 7.0448e-14 = hC/2.8011$.

$$hC = 6.582e-22 \times 2.998e8 = 2.8011 \times 7.0448e-14 \text{ MeV-meter}$$

$$\begin{aligned} G &= 1/\exp(90) \times 2.8011 \times 7.0448e-14 / (2.3206e-28 \times 1.67263e-27) \\ &\times 1.6022e-13 \\ &= 6.6744e-11 \text{ Nt} \cdot \text{m}^2/\text{kg}^2 \end{aligned} \quad (6)$$

Equation (6) is equivalent to the conventional Compton mass derivation of the gravitational constant, but it is based on a field energy, a normal proton, dark matter, and the constant $1/\exp(90)$. More can be learned about the effect of $1/\exp(90)$ on gravity by studying **Table 2**. It compares equations that use the value $1/\exp(90)$ that agree with the conventional equations for gravity and inertia.

Table 2. Equations for gravity that include $1/\exp(90)$.

								$F_i = 1.67e-27 V^2/R$		
								$R \text{ orbit} = \text{cell } r \times \exp(90) \times (M_{\text{central}}/2.49E+51)$		
		Central Mass			$r \text{ cell} = 7.045e-14 \times 10.15/ke$			$F_g = GMm/R^2 \text{ (N)}$		
Line	Orbit	(kg)	Vel m/sec	ke (MeV)	r Cell (m)	R Orbit (m)	R = GM/V ²	F _i (N)		F _{new} (N)
1	earth/sat	5.98E+24	7.43E+03	2.902E-07	2.46E-06	7.22E+06	7.22E+06	1.28E-26	1.28E-26	1.28E-26
2	sun/earth	2.00E+30	2.97E+05	4.635E-04	1.54E-09	1.51E+09	1.51E+09	9.76E-26	9.77E-26	9.77E-26
3	galaxy/star	2.00E+41	2.26E+05	2.690E-04	2.66E-09	2.60E+20	2.61E+20	3.29E-37	3.29E-37	3.29E-37
4	cluster/star	2.00E+46	4.36E+05	1.00E-03	7.15E-10	7.01E+24	7.01E+24	4.55E-41	4.55E-41	4.55E-41
5	universe/proton	2.49E+51	4.40E+07	10.15	7.05E-14	8.60E+25	8.60E+25	3.76E-38	3.76E-38	3.76E-38
6	proton/proton	1.67E-27	1.26E-12	8.318E-39	8.60E+25	7.03E-14	7.04E-14	3.77E-38	3.77E-38	3.77E-38
$F_{\text{new}} = (2.801/\text{EXP}(90) \times ke/r) / (M_{\text{cen}}/2.49E+51) / 10.15 \times 938.27 / 130 \times 1.602e-13$										

The line labelled Universe/proton is a model of a proton on a cell with kinetic energy 10.15 MeV.

The **Table 2** column labeled cell radius $r = 7.0445e-14 \times 10.15/ke$ (Equation (3)).

$$\text{Total mass} = \exp(180) \times 1.67e-27 = 2.491e51 \text{ kg} \quad (7)$$

Orbital R can be simplified to:

$$R = r \times \exp(90) \times (M_{\text{central mass}}/2.491e51) \text{ meters} \quad (8)$$

The conventional force of gravity $F_g = GMm/R^2$ in **Table 2** is compared with the inertial force, F_i and F_{new} that each use the constant $1/\exp(90)$. The three values agree for all orbits studied.

$$\begin{aligned} F_{\text{new}} &= 1/\exp(90) \times 2.801 \times ke/r \times (M/2.491e51) / 10.15 \times 938.27 / 130.16 \\ &\times 1.602e-13 \text{ N} \end{aligned}$$

$$F_{\text{new}} = 3.76e-38 \text{ Newtons} \quad (9)$$

This equation, F_{new} , can be understood as follows. The force is shifted to a low value by $1/\exp(90)$ and is proportional to the gravitational field energy $E = 2.801$ MeV. The force increases with inertial kinetic energy (ke) and further increases with small cell radius r . The ratio (central mass $M/2.49e51$) is the same ratio used to determine orbital radius R from cell radius r .

Table 2 shows equalities based on values that compare orbits for extreme conditions. **Table 2** line 5 is for a central mass equal to the total, and line 6 is for a central mass of one proton. In line 5 (labelled Universe/proton), cell size $r = 7.045e-14$ m for $ke = 10.15$ MeV, but with $\exp(180)$ protons, the orbital radius $R = 8.59e25$ m. If a proton orbits another proton at a radius of $7.045e-14$ meters, $ke = 10.15/\exp(90)$ MeV/proton.

The proton is not attracted to the center of a cell that has no mass, and it is not experiencing the huge inertial forces that would be associated with a small radius because the associated radius is huge. From a gravitational and inertial viewpoint, the cells are on a large surface near the radius of the present universe. The force $F_{\text{new}} = 3.6e-38$ Newtons is based on the central mass of the universe over a huge distance $= 7.045e-14 * \exp(90) = 8.6e25$ meters.

This is consistent with expansion that is time-dependent, having nothing to do with forces across an expanding cell. To be clear about gravity, there is a force between protons that repositions cells. The proton kinetic energy decreases with expansion according to Equation (3), and initial kinetic energy is converted to potential energy toward the end of expansion. This can be calculated from F_{new} and Orbital R , but these are macroscopic changes having nothing to do with the forces on a small expanding cell.

Knowing each proton's kinetic energy history allows properties like temperature and density to be simulated over time. For example, the temperature history $= ke/(1.5 * B)$ K, where $B =$ Boltzmann's constant $8.62e-11$ MeV/K, and the density history is based on proton mass divided by cell volume.

Table 3 provides equations for the reader to construct the straight-line model.

Table 3. Equations for straight-line expansion model.

Expansion Ratio $Z = R_{\text{final}}/R - 1$	
Exponent N	60
Kinetic energy (ke) = $7.045e-14 * 10.15/\text{cell radius (MeV)}$	10.15
Radius R at $Z = 7.045e-14 * \exp(N)$ meters	$8.04E+12$
Temperature = $ke/(1.5 * 8.602e11) * 65.5$ K after He4 fusion	$7.87E+10$
Time = $1.476e-21/(2\pi) * \exp(N)$ seconds	$0.00E+00$
Total mass = $\exp(180) * 1.67e-27$ kg	$2.49E+51$
Mass density = $2.49e51/(4/3 * \pi * R^3)$ kg/meter ³	$1.14E+12$
Cell radius $r = R/\exp(60)$ meters	
Photon density = $8 * \pi / ((1.2398e-12)^3 * (1.5 * 8.602e-11 * T)^4) * 1.78E-30$ kg/m ³	

Each variable in **Table 3** depends only on exponent N . To construct the model, write the equations in a spreadsheet. Initial radius $R = 7.045e-14 \cdot \exp(60) = 8.05e12$ meters based on $\exp(60)$ cells in each of three dimensions. Starting with $N = 60$, add small increments of N across a spreadsheet. Large R increases with $R = 7.045e-14 \cdot \exp(N)$. Expansion time $t = 1.476e-21 / (2\pi) \cdot \exp(N)$ seconds. After $N = 64.57$, multiply the temperature by 65.5 to account for fusion to 28% He4 mass fraction. The current expansion radius $R = 7.045e-14 \cdot \exp(90.384) = 1.262e26$ meters. The model energy remains constant during expansion, with potential energy plus kinetic energy = 20.3 MeV.

Check results against **Table 4**.

Table 4. Beginning and current radius and time.

Straight-Line Expansion		Beginning	Current Expansion
N exponent for number of time cycles		60	90.384
Field energy E (MeV)		2.8011	2.8011
r across circle = $hC/E = 1.97e-13/2.801 = 7.045e-14$ meters		7.045E-14	1.105
Time around circle = $2 \cdot \pi \cdot 7.045e-14 / C$ (seconds)		1.476E-21	
$E \cdot t / H = 1$	$2.801 \cdot 1.476e-21 / 4.136e-21$	1.00E+00	1.00E+00
$R = 7.045e-14 \cdot \exp(N)$ meters		8.05E+12	1.262E+26
Expansion time = time around / $2\pi \cdot \exp(N)$ seconds		2.68E+04	4.210E+17
Particle Mass (MeV)		938.27	
Kinetic energy (MeV)	$ke = 7.045e-14 \cdot 10.15 / r$	10.151	6.47E-13
Conserved E = PE + KE (MeV)		20.303	20.303
Gamma (g)	$m / (m + ke)$	0.9893	1
Velocity Ratio	$v/C = (1 - (g)^2)^{0.5}$	0.146	
$V = \text{gamma} \cdot C$		4.375E+07	11.13
Inertial F = $1.67e-27 \cdot 4.4e7^2 / (7.045E-14 \cdot \exp(90))$ Nt		3.763E-38	1.54E-64
$F = 6.6742e-11 \cdot (1.67e-27 \cdot 1.67e-27) / R^2$	Nt	3.763E-38	1.53E-64

WMAP [4] [5] and PLANCK [6] [7] mission analyses were based on the Lambda CDM expansion curve. It is compared to the straight-line model in **Figure 2** using the same time axis. The LCDM expansion curve appears to flatten late in expansion. Compared to the expected decrease, expansion was reported to be accelerating in Reference [8].

2.4. Determining Large R and Hubble's Constant H_0 from the Straight-Line Model

The sequence of events after the beginning is reviewed below [2] [3].

1) Information operations separate the logarithmic value 90 into components identified by N that add to 90. Values of N are a pattern we recognize as neutrons,

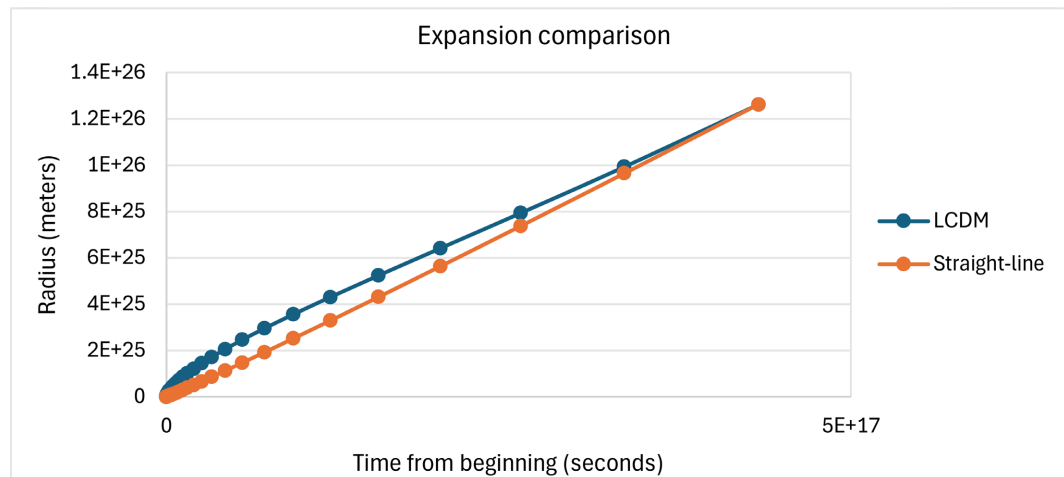


Figure 2. Comparison of expansion models.

protons, and electrons, but their associated fields are equal and opposite in energy. Each particle has probability = $1/\exp(180)$.

2) Inflation in straight-line expansion consists of duplicating particles $\exp(180)$ times. After inflation (duplication), neutrons are adjacent to one another at radius $R = hc/2.801 = 7.045e-14 \cdot \exp(60)$. This occurs at $2.68e4$ seconds.

3) There are two types of particles [1]. One is a normal neutron, but the second neutron has zero kinetic energy. It will be called dark matter and has a mass of $2.31e-28$ kg [2].

4) The normal neutron decays to an orbiting proton and initially has 10.15 MeV/proton of expansion kinetic energy (ke). The decrease in kinetic energy causes expansion. Primordial nucleosynthesis [9] occurs at kinetic energy 0.11 MeV [1]. This adds $0.28 \cdot 7.06 = 2.0$ MeV/proton to the kinetic energy as H is fused to $He4$.

5) Equality (expansion ratio $Z = 3.4e6$) is the point in expansion when mass density becomes larger than photon mass density. After equality, waves start to propagate because mass is no longer dominated by photons, and dark matter particles start to collapse into black holes. Normal matter forms Zel'dovich perturbations called pancakes [9], and dark matter is swept into webs, filaments, and voids. This is the origin of the cosmic web.

6) Zel'dovich pancakes become the large-scale Jeans radius structures observed by WMAP at the angle 0.0104 radians. The dark matter that accumulates [2] [3] [10]-[13] into black holes becomes the seeds for $1e11$ galaxies. At $Z = 88400$, the $1e11$ black holes reach $3.5e39$ Kg. This depletes dark matter and "freezes" perturbations, but expansion continues between dark holes.

7) Decoupling for normal matter occurs after expansion ratio $Z = 3677$. This breaks the plasma, and electrons orbit protons. Expansion ratio $Z = 1420$ [2] is the point Jeans criterium is met for accumulation. Accumulation of normal matter proceeds around the $1e11$ black hole seeds. After stars reach a critical mass, temperature, and pressure at about $1.6e29$ kg, they light up with fusion and are observable.

2.5. Jeans' Radius

Thermodynamic pressure is caused by particles with velocity. Jeans' analysis indicates that accumulation begins when gravitational pressure overwhelms resisting thermodynamic pressure.

The approximate value of the Jeans radius may be derived through a simple physical argument [Wiki]. One begins with a spherical gaseous region of radius, mass, and gaseous sound speed. Perturbations compress the gas slightly, and it takes time (called crossing time) for sound waves to cross the region, push back against gravity and re-establish the system's pressure balance. Gravity will contract the system if not stopped and will do so based on free-fall time. When the sound crossing time is higher than the gravity free-fall time, the gas cloud is unstable and will collapse (accumulate). Gravity free-fall time is derived below.

$$V = R/t = at$$
$$R/t = (F/M)t = tGM/R^2 = tGR * \text{density}$$
$$(R/t)/(tR) = 1/t^2 = G * \text{density}$$
$$\text{free fall time } t = 1/(G * \text{density})^{0.5}$$

(10)

If a particle starts falling, it will accelerate and fall a distance R in free-fall time t .
Jean's radius = sound speed * free fall time

(11)

After equality, waves and large-scale perturbations exist in normal matter surrounding the developing black holes. Perturbations were predicted and analyzed by Zel'dovich [9]. This caused dark matter and developing black holes to form large structures observed as the cosmic web [14]. Perturbations are normally transitory, but the black holes accumulate and stabilize the structure. Expansion of large R continues, but the space between the large-scale gravitationally bound structures expands. Table 5 describes mass accumulation. Black hole accumulation starts with a single dark matter particle in the line labelled Black hole mass and increases across Table 3 by adding "delta mass" increments from the bottom line of the table. The properties required for calculations are based on Table 1.

Table 5. Black hole formation from dark matter.

Dark Matter Accumulation							
Condition		Equality	→	←	Hidden columns		ang = J/(pi*R)
Z		3.46E+06	2.65E+06	1.80E+05	1.37E+05	1.05E+05	89590
Angle in radians	A = jeans/(PI()* Ru)	0.0017	0.0019	0.0073	0.0084	0.0096	0.010399
Jeans length*Z		6.63E+23	7.59E+23	2.91E+24	3.33E+24	3.81E+24	4.12E+24

Continued

Time (million years)	3.85E-03	5.04E-03	7.42E-02	9.71E-02	1.27E-01	1.49E-01		
R = Hubble radius during expansion meters	3.65E+19	4.77E+19	7.02E+20	9.18E+20	1.20E+21	1.409E+21	R = 1.41E+21*Z	
Kinetic energy at this point in expansion (MeV)	1.47E-04	1.12E-04	7.63E-06	5.83E-06	4.46E-06	3.80E-06		
Temperature (K)	1.E+06	9.E+05	6.E+04	5.E+04	3.E+04	3.E+04		
rho = density of hydrogen gas (kg/m³)	1.23E-08	5.47E-09	1.72E-12	7.67E-13	3.42E-13	2.123E-13		
Sound velocity Cs = 3e8/3 ^{0.5} (m/sec)	1.73E+08	1.73E+08	1.73E+08	1.73E+08	1.73E+08	1.732E+08	cs = C/3 ^{0.5}	
Sound crossing time = R/Cs shorter to be in equilibrium	2.10E+11	2.75E+11	4.05E+12	5.30E+12	6.94E+12	8.134E+12		
Gravity free fall time = 1/(G rho) ^{0.5}	1.11E+09	1.66E+09	9.34E+10	1.40E+11	2.09E+11	2.66E+11	t = 1/(6.67e-11*rho) ^{0.5}	
Jeans length = gravity free fall*Cs	1.92E+17	2.87E+17	1.62E+19	2.42E+19	3.63E+19	4.603E+19	J = cs*fft	
Gravitational energy = G*Mass*mass/R/2 (MeV)	3.80E-06	2.91E-06	1.98E-07	1.51E-07	1.15E-07	9.84E-08		
Pressure = rho*R*T = rho*8257*T (Nt/m²)	1.15E+02	3.92E+01	8.37E-04	2.85E-04	9.74E-05	5.15E-05		
Gravitational pressure = (G*m²/R²)*EXP(90)/(4*PI()*R²)	3.29E+07	1.12E+07	2.39E+02	8.17E+01	2.79E+01	1.47E+01		
r = cell size (meters)	4.84E-09	6.33E-09	9.32E-08	1.22E-07	1.60E-07	1.87E-07		
Black hole mass (KG)	2.31E-28	2.31E-28	3.44E+37	2.02E+38	9.12E+38	3.45E+39	Black hole mass (KG)	
vol = m/dens (m³)	1.88E-20	4.22E-20	2.00E+49	2.63E+50	2.67E+51	1.63E+52		
F = GM2.3e-28/(3.4e-16)²	4.14737E-16	radius r	4.78E-63	2.07E-35	3.08E+30	1.80E+31	8.17E+31	3.09E+32
a = F/M	2.07E-35	8.96E-08	8.96E-08	8.96E-08	8.96E-08	8.96E-08	8.96E-08	
V = a*delta time	5.93E-25	3.36E+03	4.94E+04	6.47E+04	8.46E+04	6.19E+04	6.19E+04	
R = (3*vol/(4*pi()))^(1/3) meters	1.65E-07	2.16E-07	1.68E+16	3.97E+16	8.60E+16	1.57E+17	1.57E+17	
Delta mass = rho*area*velocity*delta time kg	7.13E-35	4.04E-07	1.67E+38	7.10E+38	2.54E+39	2.82E+39	2.82E+39	

Number of dark matter black holes = total dark matter/3.45e39 = (129/938*2.5e51)/3.45e39 = approximately 1e11. Normal galaxies accumulate around these seeds.

2.5.1. Interpretation of the Angle 0.0104 Radians

At expansion ratio $Z = 88589$, Jean's radius is visualized and was later measured by WMAP as spots that form small angles against the sky, with radius $R = 1.409e21$ meters.

$$\text{Jeans} = C/3^{0.5} \times 1/(6.6724e-11 \times 2.12e-13)^{0.5} (6.6724e-11 \times 2.123e-13) \quad (12)$$

$$= 4.603e19 \text{ meters}$$

The angle, conserved throughout expansion, is scaled by Z from radius $1.409e21$ meters to the current large R .

$$\text{Large } R = 1.409e21 \times 89589 = 1.2622e26 \text{ meters} \quad (13)$$

$$\text{Angle check} = 2 \times 4.603e19 \times 89589 / (2 \times \pi \times 1.262e26) = 0.0104 \text{ radians} \quad (14)$$

Current large $R = Z \times R \text{ radius} = 89589 \times 1.409e21 = 1.262e26 \text{ meters.}$

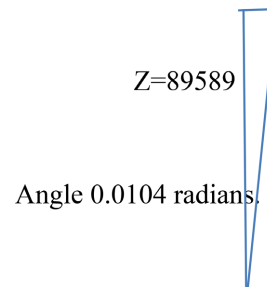


Figure 3. Geometry that determines current R from R when Jean's radius forms an angle of 0.0104.

2.5.2. Calculations for Hubble's Constant

The straight-line model **Table 3** equations yield current time $4.21e17$ sec shown on the right side of **Table 4**. **Table 6** determines the Hubble constant $H_0 = 1/4.21e17 = 2.375e-18/\text{sec} \times 3.086e22/1000 = 73.291 \text{ km/sec/mpsec.}$

Table 6. Calculations for the Hubble constant H_0 .

1.409e21	R at Z = 89589
3.45e39	BH mass
2.12E-13	Density
2.66e11	fft = $1/(6.67e-11 \times \text{rho})^{0.5}$
1.73E+08	cs = $C/3^{0.5}$
4.603E+19	J = cs*fft
0.01040	Angle radians
1.262E+26	Current Radius R = $1.409e21 \times 89589$ (m)
90.38399384	Current N = $\ln(r/R)$ from Table 2
4.21020E+17	Time = $1.47e-21/(2\pi) \times \exp(N)$ from Table 2
2.375E-18	1/time

Continued

3.086E+22	mpsec/m
73.291010	H_0 km/sec/mpsec
4.21019E+17	Current Time
3.0857E+22	mpsec/m
73.291272	H_0 km/sec/mpsec

2.5.3. Error Analysis

The proton model mass prediction [1] is compared to NIST and PDG [14] [15] data in **Table 7**.

Table 7. Accuracy of the proton model.

Particle Data Group & NIST			Simulation Result	Difference (MeV)
Neutron	939.5654133	MeV PDG	939.56541329	6.4E-09
Proton	938.2720814	MeV PDG	938.27209094	-9.6E-06
Electron	0.51099895	MeV PDG	0.51100028	-1.3E-06

Field energy = 2.8011 MeV. The delta for this energy = $\pm 1e-5$. Determining $E = 2.8011$ MeV causes H_0 error = $\pm 4e-6$. Jean's speed is certain because sound speed = $C/3^{0.5}$ is determined by plasma physics, but density is dependent on radius R at $Z = 89589$ [5]. Uncertainty in the angle for R causes Jeans to vary by $\pm 0.008\%$. Measurement uncertainty in angle 0.0104 radians is, according to the WMAP 9-year document ([5]: p. 130), angle $0.0104 \pm 2.2e-5$ radians. When the angle is adjusted in the model to 0.010422, $H'_0 = 73.291013$ is calculated by the geometry in **Figure 3** and calculations in **Table 6**. This causes an error = $\pm 2.7e-4$. Error analysis is summarized in **Table 8**.

Table 8. H_0 error analysis.

H_0 Error Analysis	
Jeans	0.008
Angle	0.00027
Energy	4.00E-06
Total $\pm$	0.008

Hubble's constant H_0 in this analysis = 73.291 ± 0.008 km/sec/mpsec.

2.6. Hubble Tension

The straight-line expansion $H_0 = 73.291$ value can be compared to published data

in **Figure 4** marked in black and blue. It represents a Wiki review of Hubble measurements from the original velocity vs. distance data in 1929 to the present. Measurement methods have improved dramatically, and recent Hubble Space Telescope [6] and James Webb Space Telescope are producing data with lower error bars. The Wiki review is below, indicating that H_0 falls into two groups. WMAP and PLANCK data are about 67.5 km/sec/mpsec and the remainder of the data clusters are around 73.

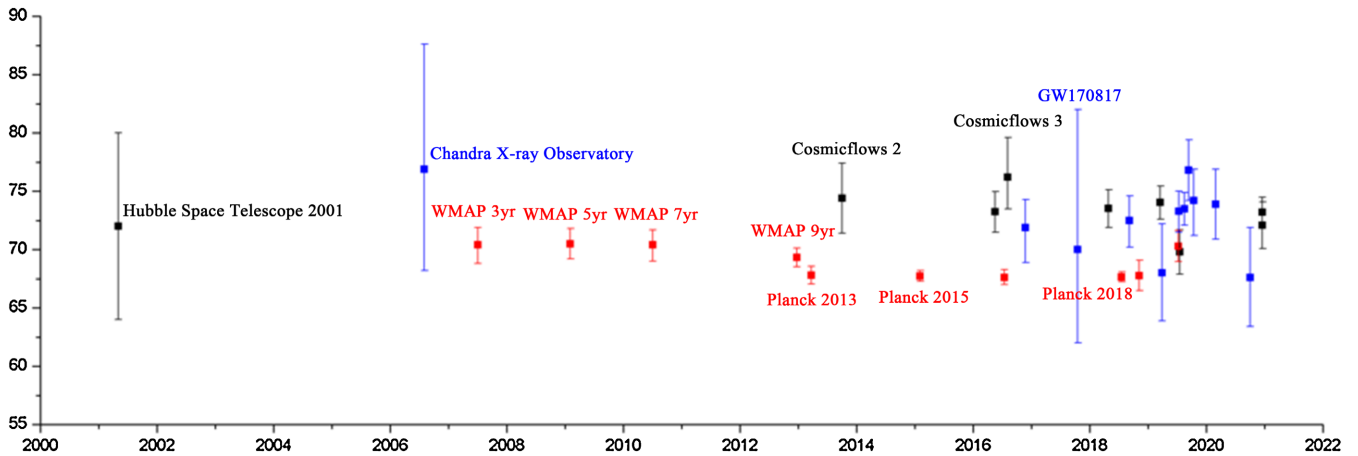


Figure 4. Copy of Wiki Hubble data summary.

2.7. Critical Density and Expansion Model Comparison

Expansion model equations help understand the difference between H_0 values derived from the straight-line model and lower WMAP and PLANCK H_0 values from the LCDM model.

2.7.1. The LCDM Outward Expansion Model

The LCDM model is based on “density” being projected outward against gravity, converting kinetic energy to potential energy (like throwing a stone into the air). The well-known [9] critical density derivation is shown below.

Derivation for Lambda CDM critical density:

$$KE = 1/2 \times MV^2 = PE = (GM^2/R^2) \times R \quad (15)$$

$$V^2/R^2 = 2 \times G \times M/R^3$$

$$V^2/R^2 = 2 \times G \times M/R^3 \times (4/3 \times \pi) / (4/3 \times \pi) = 8/3 \times \pi \times G \times \rho$$

$$\rho = (V/R)^2 / (8/3 \times \pi \times G) \quad (16)$$

The value $V/R = H_0$ with critical density = $\rho = M/(4/3 \times \pi \times R^3)$.

The Friedmann Equation.

From critical density derivation:

$$V^2/R^2 = 2GM/R^2 \quad (17)$$

$$(R/T)^2 / R^2 = 2GM/R^3 \quad (18)$$

$$R^3 = GM \times T^2$$

$$R'/R = (T'/T)^{2/3} \quad (19)$$

With G^*M a constant, the R 's in the derivation are combined; (radius'/radius) increases with (time'/time)^{2/3}. This is known as the Friedmann equation. It is the basis of the Lambda CDM expansion model and was used for data analysis from the WMAP and PLANCK missions. Their value of H_0 is also based on the CMB peak of 0.0104 radians [4] [5]. It is scaled to large R with the LCDM model and gives large $R = 1.3\text{e}26$ meters. H_0 is 1/time for that radius = $2.13\text{e}-18/\text{sec} = 67.5$ km/sec/mpsec.

The LCDM model is a composite model. Its components of normal mass, dark matter, and dark energy, shown in **Figure 5**, must add to the critical density = 1.

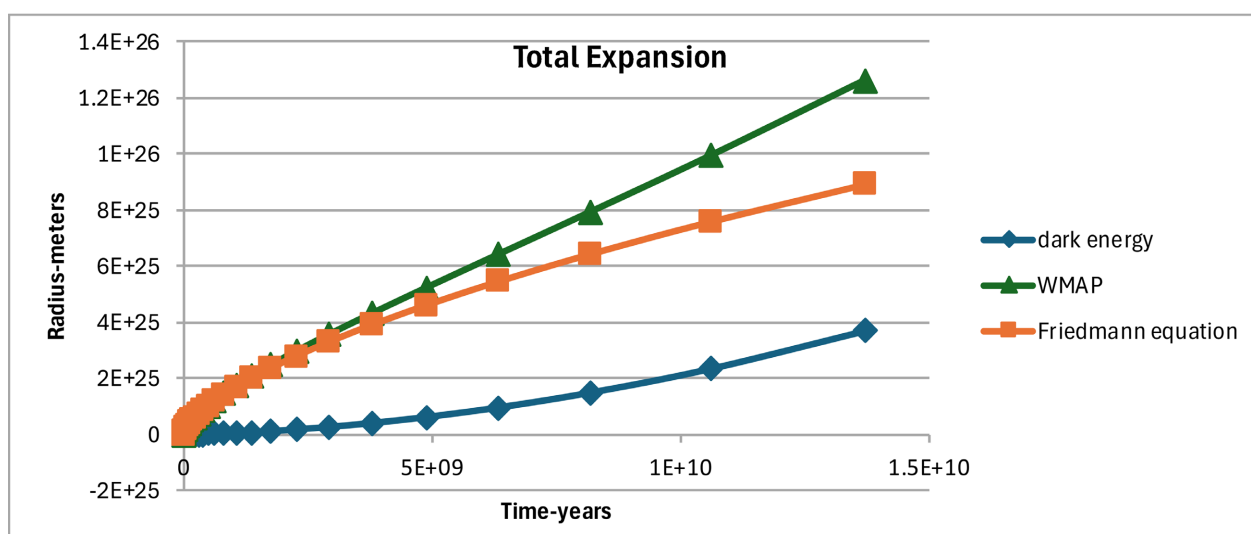


Figure 5. Components of the LCDM model.

There is a delicate balance between the Friedmann normal mass and dark matter component where $R'/R = (T'/T)^{2/3}$ and the upward slope of the dark energy component [8] that increases with R . Eventually, dark energy will dominate and the composite green curve will be upward sloping.

2.7.2. Alternate Approach to Expansion

Cells are volumes that contain one proton each, and with $\exp(180)$ cells in a 3-D universe, $R = r^* \exp(60)$. When NASA sends payloads to the Moon, the rocket points up and around the Earth into an orbit. The straight-line model is based on a proton on the surface of a cell. But topic 3.1 indicated that all $\exp(180)$ cells must be used for gravitation inside a massive universe. As tangential kinetic energy decreases, the size of the orbital R (refer to **Table 2**) increases according to Equation (3) based on energy conservation. To be clear, each individual cell is not expanding due to any force. It is expanding as a function of time. Nature is conserving energy as radius r increases.

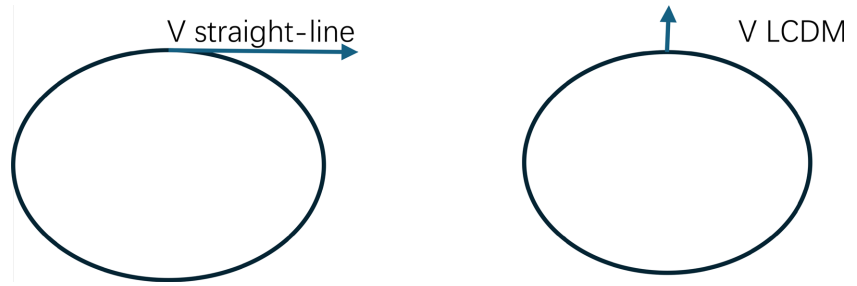


Figure 6. Straight-line expansion velocity is tangential, not radial.

Tangential velocity in **Figure 6** that describes a proton in orbit around a large central mass according to topic 3.1 provides an alternate way of exchanging kinetic energy for potential energy. Both expansion models exchange kinetic energy for potential energy according to Equation (11), but in the tangential model, velocity = Rt/T around the cell perimeter.

$$KE = 1/2 \times M (Rt/T)^2 = GM^2/Rv^2 \quad (20)$$

The kinetic energy of the cell is $1/2 M Vt^2$ with $Vt = Rt/T$. For straight-line expansion, Rt tangential and Rv vertical cannot be combined to complete the derivation of critical density in Equation (11). This also means that the Friedmann equation $R/R = (\text{Time}/\text{Time}')^{2/3}$ does not apply to the straight-line model.

The concept of critical density does not apply to tangential velocity-based expansion. Differences between the models are listed below.

1) The straight-line model gives $H_0 = 73.29$ km/sec/mpsec and the LCDM model gives 67.5 km/sec/mpsec.

2) WMAP and PLANCK report odd percentages of critical density (4.6% normal, 21% dark matter, 71.3% dark energy) that have not been substantiated. The straight-line model angle of 0.0104 radians is based on a dark matter particle new to cosmology.

3) The straight-line model combined with data from the proton model allows energy history to be calculated. Values from the proton model are key to understanding temperature-related events during expansion. The initial kinetic energy for expansion = 10.15 MeV/proton. When expansion decreases the kinetic energy to 0.11 MeV/proton, fusion to He4 multiplies the temperature by $((0.25 \times 7^4 + 0.11)/0.11) = 65$ throughout the remainder of expansion. **Table 9** is the straight-line temperature history during expansion.

WMAP measured the present sky temperature = 2.73 K. Original energy 10.15 MeV/proton and nucleosynthesis energy have been depleted in the last row of **Table 9**, and the temperature is 0.33 K. This is important because it indicates that star fusion increases sky temperature from 0.33 to 2.73 K. With this difference, WMAP and PLANCK might not have been able to shield radiation from stars from the primordial Cosmic Microwave Background [4] [5].

1) Reference [14] entitled "Origin of the cosmic web and re-interpretation of CMB" indicates that the true source of the CMB is radiation of energy from stars in the cosmic web.

2) The LCDM model is unable to explain the observation of fully formed galaxies as early as a few million years after the beginning. References [2] and [3] demonstrated that the straight-line cosmology is compatible with early observations of galaxies.

Table 9. Temperature history of straight-line expansion.

Expansion ratio $Z = R_{\text{final}}/R - 1$				
exponent N				
kinetic energy (ke) = $7.04e-14 \cdot 10.15/\text{cell radius (MeV)}$				
Radius R at $Z = 7.045e-14 \cdot \text{EXP}(N)$ meters				
Temperature = $\text{ke}/(1.5 \cdot 8.602e11)$ K*65.5 after ke = 0.11 MeV				
Time = $1.476e-21/(2\pi) \cdot \text{exp}(N)$ seconds				
1.57E+13	1.62E+11	7.12E+08	3.23E+04	1.00E+00
60	64.57	70	80	90.38
10.15	0.11	4.61E-04	2.09E-08	6.50E-13
8.04E+12	7.77E+14	1.77E+17	3.90E+21	1.26E+26
7.87E+10	5.34E+10	2.34E+08	1.06E+04	0.33
2.7E+04	2.6E+06	5.9E+08	1.3E+13	4.2E+17

3. Conclusions

Values from the proton model (2.801 MeV gravitational field energy, 10.15 MeV/proton, and exp (180) particles) support a credible expansion alternative. A straight-line expansion model was presented based on space and time and the value 2.801 MeV. The cause of expansion in this velocity C model is time. This differs from the normal assumption that expansion is based on the kinetic energy of a dense fluid. This does not change the energy balance, changing from kinetic energy to potential energy as expansion occurs.

At equality, dark matter accumulates into black holes, and perturbations leading to the cosmic web form. A Jeans analysis of the perturbation radius leads to the value $4.6e19$ meters. This determines the 0.0104 radian angle observed against the sky when black holes reach $3e40$ kg. It depletes dark matter, conserves the angle throughout the remainder of expansion, and determines the number of galaxies. The same angle measured by WMAP and the LCDM model was used to scale large R to $1.3e26$ meters associated with $H_0 = 67.5$ km/sec/psec. The straight-line model scales this angle to a large R radius = $1.262e26$ meters. The expansion rate = $1/\text{time}$ at this radius = $H_0 = 73.291 \pm 0.008$ km/sec/mpsec.

The LCDM model is currently accepted for interpretation of observations. The difference in Hubble constants published for Cepheid + supernove data and WMAP/Planck data indicates that use of the current model needs to be re-evaluated. In addition, WMAP and PLANCK documented hard-to-accept percentages of normal matter, dark matter, and dark energy that have not been substantiated. Also, the LCDM model has not explained early fully formed galaxies. The LCDM

critical density and Friedmann equation are based on radial expansion velocity causing expansion, but this is not the only approach. The straight-line model is based on tangential velocity, and neither the concept of critical density nor the Friedmann equation apply.

There are areas that need further evaluation: The straight-line temperature history indicates the CMB was overwritten by energy from stars, but searches continue for dark matter based on the original CMB interpretation. Also, the straight-line model has a dark matter particle that accelerates structure formation and is compatible with early formation of galaxies and stars, but the dark matter particle has not been experimentally verified.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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