

Structure Formation Study

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Abstract

Observations from the James Webb Telescope and Vera C. Ruben Observatory are challenging current models. Fully formed galaxies, red spots, and black holes as early as expansion ratio $Z = 20$ are issues. An alternative expansion model called the straight-line expansion model is described. It produces radius and time results similar to the conventional Lambda Cold Dark Matter (LCDM) model. Structure formation was studied and reported for the new expansion model. Progress toward a unified theory was recently published that contains a proton mass model. The proton model contains values of potential interest to cosmologists. 1) Expansion energy of 10.15 MeV/proton the mass of a “dark matter” particle that only interacts gravitationally and 2) the basis of a probabilistic argument that there are $\exp(180)$ protons in nature. The expansion kinetic energy produces an expansion temperature history that can be compared with current sky temperature 2.73 K. The “dark matter” particle cannot produce pressure that normally resists accumulation that can produce black holes. This study was carried out to determine if these three proton model values have merit in cosmology. A timeline of events was presented. Specifically, transitions called equality, decoupling and the onset of mass accumulation. This study indicates that after equality matter was influenced by Zel’dovich perturbations. A Jeans radius establishes the size of structures that form. Two features were identified that suggest a relationship between the cosmic web and Cosmic Microwave Background measurements.

Keywords

Dark Matter, Expansion, Mass Accumulation, Cosmic Web

1. Straight-Line Expansion Model [1]

The proton model is based on probability = 1.

$$P = 1 = 1/\exp(180) * \exp(180) \quad (1)$$

where $1/\exp(180)$ = probability of one proton according to the model, and $\exp(180)$

= the initial number of neutrons that decay to protons.

$$\text{Number} = \exp(180) = 1.49\text{e}78 \quad (2)$$

This agrees with estimates from Wiki regarding the Eddington number: “Plunging all these numbers into formula gives us $\approx 10^{80}$ protons in a visible universe”. Mass of “dark matter” plus protons:

$$\text{Total mass} = 1.49\text{e}78 \times (0.86 * 1.67\text{e}-27 * 0.14 * 2.3\text{e}-28) = 2.2\text{e}51 \text{ kg} \quad (3)$$

Neutrons decay to protons and are placed on a small radius defined by gravitational field energy 2.801 MeV, also found in the proton model [2].

$$r = hC/2.801 = 7.045\text{e}-14 \text{ meters} \quad (4)$$

Each proton in the model [1] has initial expansion kinetic energy = 10.15 MeV that produces velocity $0.135 * C$ around the radius of small circle radius r .

In three dimensions,

$$R = r \times \exp(180/3) = r \times \exp(60) \quad (5)$$

Each small circle (sphere) expands against gravity as kinetic energy is converted to potential energy. Small radius r increases during expansion with the gravitational constant G remaining constant.

$$\begin{aligned} G &= rV^2/m \\ G/G &= 1 = (r_0 \times ke_0)/(r \times ke) \\ r &= 7.045\text{e}-14 \times 10.15/ke \end{aligned} \quad (6)$$

The goal of **Table 1** is to provide equations for the reader to construct a straight-line expansion model.

Table 1. Equations for straight-line expansion.

Expansion ratio $Z = R_{\text{final}}/R - 1$	1.57E+13
exponent N	60
kinetic energy (ke) = $7.04\text{e}-14 * 10.15/\text{cell radius (MeV)}$	10.15
Radius R at $Z = 7.045\text{e}-14 * \text{EXP}(N)$ meters	8.04E+12
Temperature = $ke/(1.5 * 8.602\text{e}11) * 65.5 \text{ K}$	7.87E+10
Temperature high $K = \text{low } T * 70$	7.87E+10
Time = $1.476\text{e}-21/(2\pi) * \exp(N)$ seconds	2.7E+04
	2.48727E+51
mass density = $2.49\text{e}51/(4/3 * \pi * R^3)$ kg/meter³	1.14E+12
cell radius (meters) = $R/\exp(60)$	7.04E-14
mass density high = $\text{low} * 4$ (Kg/meter³)	
photon density (Kg/meter³)	2.51E+11
photon density/mass density	2.20E-01

$$\text{Photon density} = 8 \times \pi / (1.24\text{e}-12)^3 \times (1.5 \times 8.617\text{e}-11 \times T)^4 \times 1.87\text{e}-30 \text{ kg/m}^3 \quad (7)$$

Each column of **Table 1** depends only on the exponent $\exp(N)$. To construct

the model, write the equations in a spread sheet. Start with $N = 60$ and add small increments. After $N = 64.57$ multiply temperature by 65.5 K to account for primordial nucleosynthesis. Stop at $N = 90.384$ where the Hubble constant = 73.16 km/sec/mpsec.

The straight-line model [2] [3] is a radius vs time model with time = $1.47e-21/(2\pi) \cdot \exp(N)$ seconds. Radius $R = 7.045e-14 \cdot \exp(N)$ expands outward at lightspeed since $C = R/T = 2\pi \cdot R/(2\pi \cdot T)$. Beginning and current conditions are in **Table 2**.

Table 2. Straight-Line expansion beginning and current values.

Straight-line expansion	cell bj162	beginning	now
		Mass + Ke	Mass + Ke
N exponent for number of time cycles		60	90.3784
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	1.00E+00
time around circle = $2\pi \cdot 7.045e-14/C$ (seconds)		1.476E-21	1.263E+26
$E \cdot t/H = 1$	$2.801 \cdot 1.476e-21/4.136e-21$	1.00E+00	4.21E+17
$R = 7.045e-14 \cdot \exp(60)$ meters		8.05E+12	
time across radius = time around/ $2\pi \cdot \exp(60)$ seconds		2.68E+04	1.106
Particle Mass (MeV)		938.27	
r cell = $7.045e-14 \cdot 10.15/ke$ meters		7.0446E-14	
Mass proton (kg)		1.6726E-27	6.47E-13
Universe mass = $1.67e-27 \cdot \exp(180)$ kg		2.20E+51	20.3
Kinetic Energy (MeV)	$KE = 7.045e-14 \cdot 10.15/R$	10.1513	1
conserved E = PE + KE (MeV)		20.300	
Gamma (g)	$m/(m + ke)$	0.9893	11.13
Velocity Ratio	$v/C = (1 - (g)^2)^{0.5}$	1.4592E-01	
$V = \text{gamma} \cdot C$		4.375E+07	
F = $6.6742e-11 \cdot (1.67e-27^2)/7.045e-14^2 N$		3.762E-38	1.54E-64
Inertial F = $1.67e-27 \cdot 4.4e7^2/(7.045e-14 \cdot \exp(90))N$		3.763E-38	1.53E-64
$F = 6.6742e-11 \cdot (1.67e-27 \cdot 1.67e-27)/r^2 N$		3.763E-38	

The column on the left of **Table 2** contains values for the beginning of expansion. The initial gravitation force resisting expansion = $3.76e-38$ N. This decreases as expansion occurs. Potential energy increases according to integral $F \cdot dr$.

$$\begin{aligned}
 &\text{Potential energy increase} \\
 &= 0.5 \times 3.76e-38 \times (8.59e25 - 7.045e-14) / (1.6022e-13) \quad (8) \\
 &= 10.15 \text{ MeV/proton}
 \end{aligned}$$

The column of the right side of **Table 2** contains current values. The model is

zero net energy.

$$KE + PE = 20.3 \text{ MeV/proton} \quad (9)$$

Figure 1 compares straight-line expansion with Lambda Cold Dark Matter (LCDM) expansion reported by the WMAP and PLANCK missions [4]-[6].

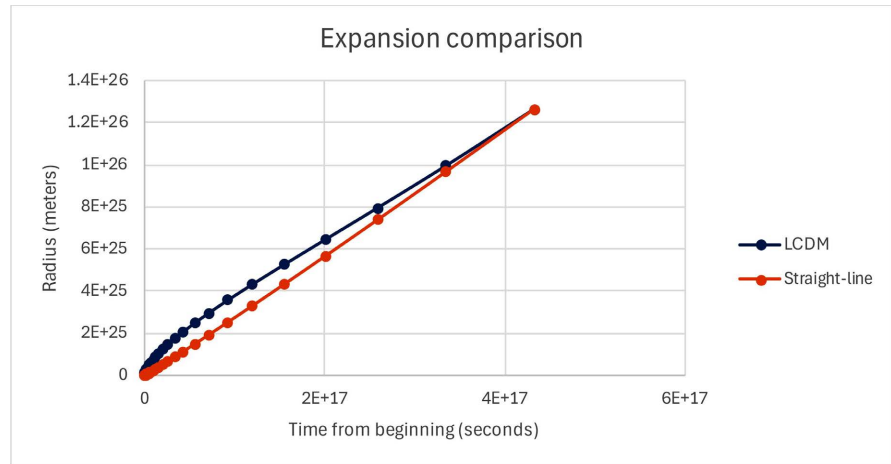


Figure 1. Comparison of expansion models.

The current radius is determined by Cepheid variables [7] [8]. Hubble constant,

$$H_0 = 2.375e-18/\text{sec} = 1/4.21e17 \text{ sec.} \quad (10)$$

$$\text{Elapsed time} = 2.35e-22 \times \exp(90.384) = 4.21e17 \text{ seconds} = 13.35 \text{ B years} \quad (11)$$

$$\text{Large } R = 7.045e-14 \times \exp(60) + 4.21e17 \times 3e8 = 1.26e26 \text{ meters} \quad (12)$$

At elapsed time 13.35 B years and large $R = 1.26e26$ meters both models agree.

2. Inflation and Expansion History

The sequence of events after the beginning are listed below.

1) Information operations separate the logarithmic value 90 into components identified by N values that add to 90. Values of N are a pattern we recognize as neutrons, protons, and electrons but their associated fields are equal and opposite energy. Each particle has probability value $1/\exp(180)$.

2) Inflation in straight-line expansion consists of duplicating particles $\exp(180)$ times. After inflation neutrons are adjacent to one another at radius,

$$R = hC/2.801 = 7.045e-14 \times \exp(60) \quad (13)$$

Table 2 indicates that this occurs at 2.68e4 seconds.

3) There are two types of particles [1]. One is a normal neutron, but the second particle has zero kinetic energy. It will be called dark matter.

4) The normal neutron decays to an orbiting proton [2] and initially has 10.15 MeV/proton of expansion kinetic energy (ke). Expansion reduces the kinetic energy. Primordial nucleosynthesis occurs at kinetic energy 0.11 MeV [9] [10]. This adds

$$dE = 0.28 \times 7.06 = 2.0 \text{ MeV/proton} \quad (14)$$

to expansion kinetic energy as H is fused to He4.

5) After equality waves start to propagate because mass is no longer dominated by photons [11]. At equality (expansion ratio $Z = 3.4e6$) dark matter particles start to collapse into black holes. Normal matter perturbations form Zel'dovich pancakes [11] and the dark matter is swept into webs, filaments, and voids. This is the origin of the cosmic web.

6) The black holes that form from dark matter become the seeds for $1e11$ galaxies. At $Z = 88,400$ the $1e11$ black holes reach $1e40$ Kg. This depletes dark matter. The black holes swept into Zel'dovich pancakes become the large-scale structure (LSS) observed by WMAP at the angle 0.0104 radians.

7) Decoupling for normal matter occurs after $Z = 3677$. This breaks the plasma and electrons orbit protons. Expansion ratio $Z = 1420$ is the point Jeans criterium is met for accumulation. Accumulation of light matter proceeds around the 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.

2.1. Jeans Radius

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

According to Wiki, the approximate value of the Jeans radius may be derived through a simple physical argument. 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.

$$\begin{aligned} V &= R/t = at \\ R/t &= (F/M)t = tGM/R^2 = tGR \times \text{density} \\ (R/t)/(tR) &= 1/t^2 = G \times \text{density} \\ \text{free fall time } t &= 1/(G \times \text{density})^{0.5} \end{aligned} \quad (15)$$

If a particle starts falling it will accelerate and fall a distance R in free fall time t .

2.2. Temperature History of Expansion

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, fusion to He4 $dE = 2.0$ (Equation (14)) increases temperature by a factor of 65.5 . These

values allow expansion temperature history be determined (**Table 3** below).

Table 3. Temperature history of straight-line expansion.

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

Original energy 10.15 MeV/proton and nucleosynthesis energy have been depleted in the last row of **Table 3** and the final temperature = 0.33 K. WMAP measured the current sky temperature = 2.73 K. The ratio 2.73/0.33 = 8.3 is important because it indicates that primordial CMB sky temperature variations have been overwritten. This changes the interpretation of WMAP measurements.

3. Details of Expansion History

3.1. Equality

Equality is the point in expansion where mass density is equal to photon mass density. After equality mass dominates and waves are free to propagate. The conditions at equality for straight-line expansion are in **Table 4**.

Table 4. Conditions at equality.

Expansion ratio $Z = R_{\text{final}}/R - 1$	4.13E+06	3.55E+06
exponent N	75.15	75.3
kinetic energy (ke) = $7.04e-14 \cdot 10.15/\text{cell radius}$ (MeV)	2.67E-06	2.30E-06
Radius R at $Z = 7.045e-14 \cdot \text{EXP}(N)$ meters	3.06E+19	3.55E+19
Temperature = $ke/(1.5 \cdot 8.602e11)$ K*65.5 after ke = 0.11 MeV	1.36E+06	1.17E+06
Time = $1.476e-21/(2\pi) \cdot \exp(N)$ seconds	1.0E+11	1.2E+11
	2.487E+51	2.48727E+51
mass density = $2.49e51/(4/3 \cdot \pi \cdot R^3)$ kg/meter³	2.08E-08	1.33E-08
cell radius (meters) = $R/\exp(60)$	2.68E-07	3.11E-07
mass density high = low*4 (Kg/meter³)		
photon density (Kg/meter³)	2.22E-08	1.22E-08
photon density/mass density	1.07E+00	9.19E-01
	Equality	Equality

$$\text{Mass density} = 2.49\text{e}51 / (4/3 \times \pi R^3) = 2.75\text{e}-8 \text{ kg/meter}^3 \quad (16)$$

Photon mass density

$$\begin{aligned} &= 8\pi / 1.24\text{e}-12^3 \times (1.5 \times 8.617\text{e}-11 \times T)^4 \times 1.87\text{e}-30 \\ &= 3.2\text{e}-8 \text{ kg/meter}^3 \end{aligned} \quad (17)$$

3.2. Large-Scale Structure and Black Holes

Waves and large-scale perturbations exist in normal matter surrounding the developing black holes. Perturbations, called pancakes, were predicted and analyzed by Zel'dovich [9]. This caused dark matter and developing black holes to form large structures we call the cosmic web. Perturbations are normally transitory, but the black holes swept into the structure become stable. Expansion of the universe continues and the space between black holes expands. **Table 5** below details the accumulation process based on a "Rapid cosmic evolution" [12]. The calculations below start with a single dark matter particle in line 12 and end when the dark matter is depleted at mass 3.6e39 kg. This establishes the number of galaxies at $3.4\text{e}50/3.6\text{e}39 = 1\text{e}11$.

Table 5. Black hole accumulation.

Dark matter accumulation							
Condition			Equality		Hidden columns		ang = J/(pi*R)
Angle in radians	A = jeans/(PI()*(Ru)		0.0017	0.0019	0.0084	0.0096	0.0110
Jeans length*Z			6.63E+23	7.59E+23	3.33E+24	3.81E+24	4.36E+24
time (million years)			3.86E-03	5.05E-03	9.71E-02	1.27E-01	1.66E-01
R = Hubble radius during expansion meters			3.65E+19	4.77E+19	9.18E+20	1.20E+21	1.57E+21
Expansion ratio Z = Rf/R - 1			3.46E+06	2.65E+06	1.37E+05	1.05E+05	8.03E+04
rho = density of hydrogen gas (kg/m³)			1.23E-08	5.47E-09	7.67E-13	3.42E-13	1.53E-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
sound crossing time = R/Cs	shorter to be in equilibrium		2.10E+11	2.75E+11	5.30E+12	6.94E+12	9.08E+12
gravity free fall time = 1/(G rho) ^{0.5}			1.11E+09	1.66E+09	1.40E+11	2.09E+11	3.13E+11
Jeans length = gravity free fall*Cs			1.92E+17	2.87E+17	2.42E+19	3.63E+19	5.43E+19
Temperature (K)			1.E+06	9.E+05	5.E+04	3.E+04	3.E+04
Black hole mass M (KG)			2.31E-28	2.31E-28	2.11E+38	9.54E+38	3.62E+39
vol = m/dens (m³)			1.88E-20	4.22E-20	2.75E+50	2.79E+51	2.37E+52
F = (G*M*2.3e-28/3.4e-16) ²	4.117E-16	radius r	4.85E-63	2.10E-35	1.92E+31	8.67E+31	3.29E+32
a = F/M			2.10E-35	9.09E-08	9.09E-08	9.09E-08	9.09E-08
V = a*delta time			6.02E-25	3.41E+03	6.57E+04	8.59E+04	1.12E+05
R = (3*vol/(4*pi)) ^(1/3) meters			1.65E-07	2.16E-07	4.03E+16	8.73E+16	1.78E+17
delta mass = rho*area*velocity*delta time kg	8.5E+39		7.24E-35	4.10E-07	7.43E+38	2.66E+39	8.46E+39

3.2.1. Interpretation of the Angle 0.0104 Radians

At expansion ratio $Z = 80300$, the Jeans length = 5.43×10^{19} meters is visualized as a spot that forms a small angle against the sky radius = 1.57×10^{21} meters (values in red from **Table 5**).

$$\text{Angle} = 2 \times 5.43 \times 10^{19} / (2 \times \pi \times 1.57 \times 10^{21}) = 0.0104 \text{ radians} \quad (18)$$

The angle is conserved throughout expansion and can be used to estimate current large R .

$$\text{Large } R = 1.57 \times 10^{21} \times 80300 = 1.26 \times 10^{26} \text{ meters} \quad (19)$$

The angle 0.0104 radians was observed by WMAP. According to their documentation, the value 0.0104 radians was the size of the peak micro-degree variation in CMB [4] [11]. **Figure 2** presents the geometry that allows overall radius (large R) to be determined from the 0.0104 radian distance between “spots” that this document identifies as galaxies. They were formed around black holes at $Z = 9300$ but the distance between them expanded with the universe.

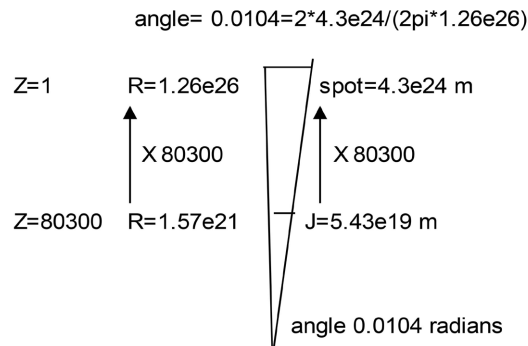


Figure 2. Geometry that determines R from Jeans.

WMAP documented CMB variations with multi-pole moments. This analysis describes volumes within other volumes and can be converted to the radius of each volume. Multipole moment 220 is radius 4.12×10^{24} meters. The angle 0.0104 is interpreted as large-scale structure. **Table 6**, line 1 below is the size of features (peaks and valleys) in the CMB documented by WMAP [4]. The features are labelled as cosmic web features in **Table 6**. The large-scale structure is associated with Zel’dovich pancakes. The column labelled galaxies is the distance between galaxies identified in **Table 7** below. This structure forms around the black holes. The remainder of the features are described in reference 13 using cosmic web data.

Table 6. Cosmic web structure.

		short	long				
galaxies	between	filaments	filaments	walls	voids	Large-scale structure	
2000	1700	1200	850	546	411.7	220	Multipole moment
5.72×10^{22}	1.03×10^{23}	2.20×10^{23}	4.59×10^{23}	1.04×10^{24}	2.00×10^{24}	4.12×10^{24}	Radius R meters

3.2.2. Mass and Energy Balance

Equation (2) number of particles = $1.49e78$ is proportioned into two parts by the mass of dark matter particles and normal matter in **Table 7**. Each mass is accounted for down through the table as it is partitioned into black holes and normal matter galaxies that form around the black holes. The number and distance between features are determined from current density. The goal of the table is to account for all mass and energy as it changes form.

Table 7. Distance between galaxies.

Fraction of total mass	0.14	0.86	1.00
	Dark matter	Dark + normal	
	Black holes	Galaxies of stars	Total mass
Expansion ratio Z	80,300	3677	$2.20E+51$
percentage of mass used			0.95
density for column kg/m^3	$4.11E-29$	$2.95E-28$	
mass	$2.9E+50$	$1.80E+51$	$2.09E+51$
Average mass	$3.3E+39$	$2.0E+40$	
N stars		$1.0E+21$	
N galaxies	$1.0E+11$	$1.0E+11$	
Vol of mass	$8.0E+78$	$8.0E+78$	
Vol of each type	$8.0E+67$	$8.0E+67$	
$d = 2*(3*v/(4*pi))^{(1/3)}$	$5.3E+22$	$5.3E+22$	

There is evidence that galaxies are represented in the CMB at multipole moment 2000. The distance $5.7e22$ meters on the left side of **Table 7** is the key. The center column of **Table 7** shows $1e11$ galaxies after accumulation around the central black hole seeds in the left column. Volumes = mass/density allows the distance between galaxies to be calculated at the current time. In the center column of **Table 7**, the distance is $5.3e22$ meters between galaxies.

$$\text{distance} = 2 \times (3 \times \text{Volume} / (4\pi))^{1/3} = 5.3e22 \text{ meters} \quad (20)$$

This is comparable to the **Table 7** left column distance $5.7e22$ meters and an important clue that the small CMB observations are galaxies. The left column of **Table 7** has the same spacing. This is consistent with normal matter galaxies forming around dark holes.

Energy balance: The proton model provided an initial value of 10.15 MeV/proton. Nucleosynthesis added energy but at the end of expansion the temperature was only 0.33 K. A calculation in topic 3.6 “Number of stars,” adds energy from $6.6e20$ stars to achieve the measured sky temperature 2.73K.

Mass balance: The proton model identifies total mass = $2.42e51$ kg (Equation (3)). Data indicates that the average mass of stars = $2e30$ kg. Data for the number of galaxies is $1e11$ to $2e11$. The left-hand column of **Table 7** has mass fractions

0.135 and 0.855. Densities is lower in the dark matter column because particles have less mass. There are several numbers that affect one another but the table accounts for 95% of $2.2e51$ kg in the proton model [2]. The remaining 5% is normal matter inside galaxies but between stars. The galaxies and stars are gravitationally bound but the distance between them expands. Volumes are mass/current density. This allows distance between features to be calculated and compared to current observations. Observations indicate large variations in star mass, galaxy size and type. The average galaxy mass in **Table 7** is $2e40$ kg. The table is based on averages, but the overall mass balance supports the proton model total mass.

3.3. Decoupling

The SAHA criterion (Equation (21)) predicts the point where expansion has reduced temperature to the point electrons settle into orbits and become atoms. This is called decoupling and occurs when the SAHA value exceeds unity. **Table 8** below shows the straight-line expansion model mass density and photon mass density as a function of time. Decoupling occurs at $Z = 9300$.

Table 8. Decoupling.

Expansion ratio $Z = R_{\text{final}}/R - 1$	9.36E+03	8.81E+03
exponent N	81.24	81.3
kinetic energy (ke) = $7.04e-14 \times 10.15/\text{cell radius (MeV)}$	6.05E-09	5.70E-09
Radius R at $Z = 7.045e-14 \times \text{EXP}(N)$ meters	1.35E+22	1.43E+22
Temperature = $\text{ke}/(1.5 \times 8.602e11)$ K*65.5 after ke = 0.11 MeV	3.07E+03	2.89E+03
Time = $1.476e-21/(2\pi) \times \exp(N)$ seconds	7.2E+12	7.6E+12
	2.487E+51	2.487E+51
mass density = $2.49e51/(4/3 \times \pi \times R^3)$ kg/meter³	2.42E-16	2.02E-16
cell radius (meters) = $R/\exp(60)$	1.18E-04	1.25E-04
mass density high = low*4 (Kg/meter³)		
photon density (Kg/meter³)	5.85E-19	4.60E-19
photon density/mass density	2.42E-03	2.28E-03
decoupling		
SAHA	6.02E-02	1.31E+00
Z expansion ratio	9356.7	8811.8

$$\text{SAHA} = 4 \times 2^2 / \pi^{0.5} \times 1/3.63e20 \times 7.5e-10 \times (T/0.511)^{3/2} \times \exp(1.36e-5/8.62e-11 \times T) \quad (21)$$

Before decoupling ($Z = 9300$), the normal matter universe consisted of plasma. At decoupling the speed of sound drops from $V = 3e8/3^{0.5}$ to a much lower value. This is the start of what cosmologists call the dark ages. Hydrogen gas absorbs light at the Lyman-alpha wavelength (Wiki) and obscures observations.

3.4. Jeans Analysis for Start of Normal Mass Accumulation

The Jeans radius analysis is shown below for the start of normal matter accumulation. Density, temperature, and radius from the straight-line expansion model are in **Table 9**.

Table 9. Jeans analysis for star accumulation.

	Z	1421	1086
Volume in radius R	$V = 4/3\pi R^3$	2.93E+69	6.56E+69
Volume divided into 1e11 galaxies		2.93E+58	6.56E+58
Radius of galaxy volumn	$R = (3*Vol/(4*\pi))^{(1/3)}$	1.9E+19	2.5E+19
Speed of sound $cs = (1.4*8.62e-11*T/density)^{0.5}$		2.58E+05	3.37E+05
Galaxy R/speed of sound (R/cs)		7.43E+13	7.43E+13
Free fall time = $(1/G*density)^{0.5}$		9.76E+13	1.46E+14
Jeans length = $cs*free\ fall\ time$		2.51E+19	4.92E+19

At straight-line expansion ratio $Z = 1421$ the Jeans criteria for accumulation of H and He4 mass is satisfied. The sound crossing time analysis is based on this radius. For this radius gravity free fall time dominates sound speed. This means the volume is unstable and will collapse into stars. The volume that collapses has a Jeans radius of $2.5e19$ meters. The volume*(density at $Z 1420$) = $6e40$ kg is the mass enclosed by this radius. This volume has the potential of becoming stars. The initial radius between galaxies that form will be about $2.6e19$ meters.

Rapid Cosmic Evolution

An equation called the touch down equation is derived below.

$$\begin{aligned}
 R = at^2 &= 0.5 \times GM / R^2 \times (2R/at)^2 = 2GM / (at)^2 \\
 0.5at^2 &= 2GM / (at)^2 \\
 a^3t^4 &= RGM \\
 a &= (4GM/t^4)^{1/3}
 \end{aligned} \tag{22}$$

Mass must travel inwardly distance L to reach the accumulation surface. The derivation indicates that as mass gets closer, its acceleration increases because gravity is an inverse square phenomenon. The acceleration causes mass M to traverse R toward the center in delta time t . Mass inside distance R (volume $4/3*\pi*L^3$) will accumulate to a point if not stopped.

1) Low-pressure volume around the Jeans collapse.

The touch down equation incrementally crunches mass to the density of a star after mass becomes unstable. A low-pressure volume develops around the collapsed mass.

2) Backfilling the low-pressure volume.

The flow calculated below backfills the low-pressure volume [12]. **Table 10** be-

low details the accumulation process. The accumulation calculation starts with a single proton (line 3). The volume of each incremental mass = mass/density (density from the straight-line expansion model). Its associated radius R is labelled R . This radius is the basis for the surface area that mass flows through at velocity V to accumulate with the starting mass. The flow velocity is derived from expansion kinetic energy. Its initial value is 71 meters/sec. Mass/density is converted to volume, and its associated radius is used to determine the flow surface area ($4\pi R^2$). Incremental mass = $\rho \cdot \text{area} \cdot \text{velocity} \cdot \text{delta time}$ where ρ is the density at this point in expansion. Delta time is the interval between step wise mass accumulation calculations. Delta mass in the bottom line is added to line 3 mass for the next increment.

Galaxy mass accumulation can be early ($Z = 1420$ to present) but this analysis is low since dark matter black holes accelerate accumulation.

Table 10. Accumulation simulation.

Z expansion ratio		1421.11	1085.82	829.58	1.93	1.24	0.71	0.31	0.01
mass star (Kg)	1.97E+30	1.67E-27	2.28E-08	1.14E+05	1.62E+30	1.72E+30	1.81E+30	1.89E+30	1.97E+30
vol = m/dens (m ³)		1.97E-09	6.00E+10	6.71E+23	2.17E+56	5.17E+56	1.22E+57	2.86E+57	6.65E+57
Velocity = (2*(expansion ke)/1.673E-27*1.6e-13) ^{0.5} m/sec		7.12E+01	6.22E+01	5.44E+01	3.23E+00	2.83E+00	2.47E+00	2.16E+00	1.89E+00
R = (3*vol/(4*pi)) ^(1/3) meters		7.77E-04	2.43E+03	5.43E+07	3.73E+18	4.98E+18	6.63E+18	8.80E+18	1.17E+19
delta mass = rho*area*velocity*delta time kg		2.28E-08	1.14E+05	2.90E+13	1.01E+29	9.20E+28	8.33E+28	7.51E+28	6.74E+28

The accumulation calculated above is for a star, but stars are forming throughout the 1e11 galaxies (Table 8). Figure 3 and Figure 4 are plots of accumulation from Table 10. Figure 4 indicates that stars can easily form during this early period, but do not light up until around 1.6e29 kg ($Z = 40$).

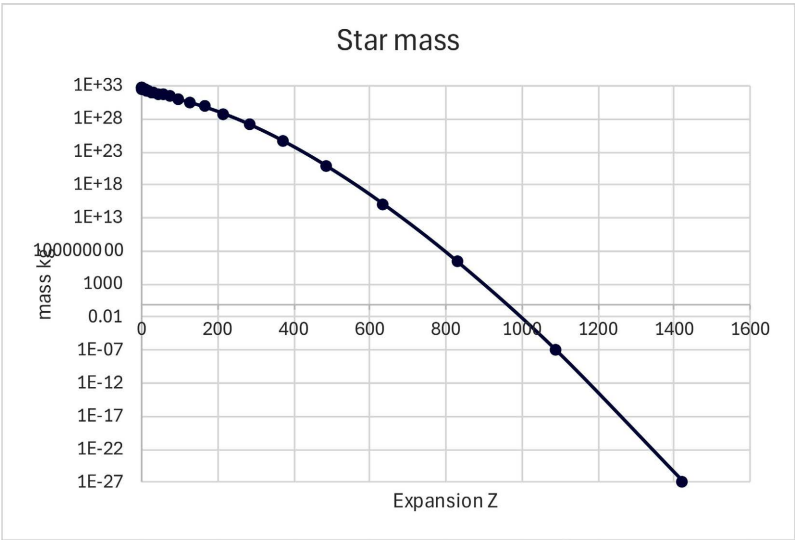


Figure 3. Star accumulation from $Z = 1400$.

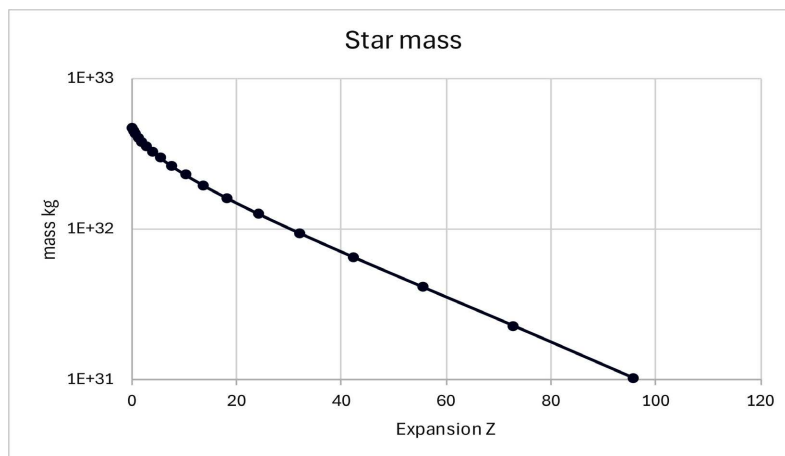


Figure 4. End of Figure 3, star accumulation curve.

3.5. Number of Stars

Based on the proton model, the total mass of the universe = $2.2e51$ kg. Table 8 indicates that 95% of the universe mass $2.2e51$ kg has been converted to galaxies of stars surrounding black hole seeds. The number of stars was estimated based on the current temperature = 2.725 K. In the straight-line model, the temperature at $1.26e26$ meters radius would be only 0.33 K, not the measured 2.725 K. The calculation for sky temperature in Table 11 is based on multiplying the energy radiated from the $6e18$ m² surface area of stars at surface temperature 5778 K. In the example below, the energy for each star is estimated. The Stefan Boltzmann constant = $3.54e5$ MeV/(m²*K⁴) is used below.

$$\text{Energy/star} = 3.54e5 \times 6e18 \times 5778^4 = 6.8e33 \text{ MeV} \quad (23)$$

For $6.6e20$ stars, the total energy is $4.5e54$ MeV. This energy is radiated to the surface area of the universe at radius $R = 1.26e26$ meters.

$$\text{Area} = 4 \times \pi \times 1.26e26^2 = 2e53 \text{ m}^2 \quad (24)$$

$$K^4 = (4.5e54/2e53)/3.54e5 = 32K^4 \quad (25)$$

$$(32K^4)^{1/4} = 2.728K \quad (26)$$

Table 11 is for the end of expansion, where the sky temperature is 2.73 K. The energy radiated from stars is calculated showing that $6.6e22$ stars raises the sky temperature. The fourth root of $32 K^4$ is the required star fusion to raise the temperature from 0.33 K to 2.728 K.

Table 11. Star energy required to achieve 2.75 K.

0.33	Temperature w/o stars
$6.97E+08$	Radius of star = $6.96e8 \times (M_{\text{star}}/M_{\text{sun}})^{(1/3)}$
$6.10E+18$	area of star surface (meter ²)
5778	Temp of Star surface (K)

Continued

6.80E+33	Area*Temp ⁴	
4.49E+54	Stars*area*Temp ⁴	
1.26E+26	Ru = Sky radius (m)	1.00E+00
2.00E+53	Sky area (m ²)	70
32.043	(Stars*area*Temp ⁴)/(Sky area)	
2.730	Measured temperature (K)	

4. Summary

A timeline of events related to structure formation was presented based on a straight-line expansion model and values from a proton mass model. A particle of mass $2.3\text{e}-28$ kg without kinetic energy appears in the model. It is credible because it appears in a calculation for the gravitational constant [2]. This particle's only interaction is gravity and is called dark matter.

Jean's concepts provide the size of structures and the point that normal matter accumulation can begin. After equality, Jean's radius was $5.4\text{e}19$ meters at $Z = 80300$. Perturbations called Zel'dovich pancakes distributed dark matter into large structures we identify now as the cosmic web. The dark matter black holes that formed are gravitationally bound and expansion between structures conserves angle 0.0104 radians throughout expansion. Calculations suggest that the Jeans $5.4\text{e}19$ meter structure was observed by WMAP as the angle 0.0104 against the sky at radius $4.3\text{e}24$ meters. The conserved angel was used to estimate the size of the universe. The result compares favorably with the Hubble derived radius $1.26\text{e}26$ meters.

Formation of galaxies is a two-step process 1) dark matter forms black holes and 2) normal matter accumulates around the black holes. Dark matter starts accumulating soon after equality and forms $1\text{e}11$ black hole seeds. At $Z = 1420$ normal mass accumulates around the dark holes. Influence of the black hole was studied in reference 14 and 15. Stars could be observable when their mass reaches $1.6\text{e}29$ kg at $Z = 40$. This is extremely early compared to observations [13].

An approximate mass balance was presented for a combination of values from the proton model and data for star mass and galaxy numbers. The proton model gives a probabilistic argument for the mass of the universe. This mass was successful as the basis of the mass balance. Mass/current density allowed an analysis of structure spacing. The result for galaxies was $5.3\text{e}22$ meters. This is the distance associated with WMAP power spectrum multi-pole moment = 2000 with size $5.7\text{e}22$ meters [14]. This further supports the relationship between CMB measurements and structure formation [15]. An energy balance indicates that the sky temperature would be lower without radiation from stars. This may be the source of CMB, not early light [16].

There are huge variations in nature and many surprises. The straight-line model time and the geometry of Figure 2 lead directly to a specific Hubble constant [17]. There is a fundamental difference between the straight-line model and the LCDM

model [18] that might be leading to inaccurate percentages of matter, dark matter and dark energy. The information presented is preliminary, but it has the potential of relieving tension regarding observation of early black holes and galaxies. Values in the proton model are valuable.

Conflicts of Interest

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

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