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A new single-length-scale similarity solution for an infinite homogeneous expanding universe using Einstein's averaged field equations.

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An Alternative Cosmological Model for an Expanding Universe

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Contents

http://www.turbulence-online.com/Publications/Purdue_April_2022_Paper.pdf

Universe Composition

(What many physicist say, but not all believe)

- **Only 5% Normal Matter!!!!   27% Dark Matter   68% Dark Energy**
- **These are called `DARK' since if present it does not radiate and is therefore invisible.**
- **All of these `beliefs  of existence of dark matter and energy' are based on the failure of `standard' (*FLRW-based)* cosmological models to explain the data.**
- **But many are looking for it – so far in vain. After 30 years!**
- **And finally there is the quantum field theory (QFT) estimate of the Big Bang energy which is off by 120 orders of magnitude!!!!**
- **Clearly we need a better idea!**

What this talk is about!

- It is about taking ideas from turbulence theory and applying them to Einstein's equations averaged over huge regions of space – millions of galaxies.
- These `averaged' equations are highly non-linear and not closed.
- `Not closed' means the mean flow loses energy to smaller scales of motion, and those create even smaller scales until viscosity kills them.

"Big whirls have little whirls that feed on their velocity, and little whirls have lesser whirls and so on to viscosity."—Lewis Fry Richardson.

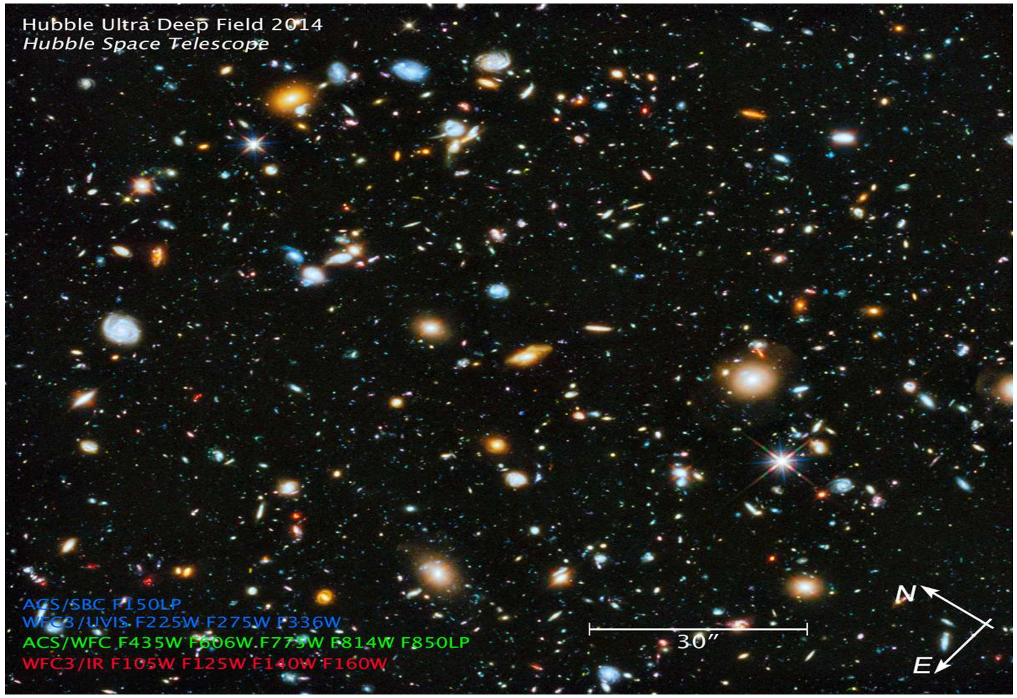
- As a consequence of this, energy is NOT conserved at any level

  – only in aggregate when all levels of scales are considered together.

How turbulence behaves and why the universe is similar

- The nice thing about turbulence in infinite domains and with simple initial conditions is that the strong non-linearities often dictate the form of the solution even though we can not solve the equations directly.
- Often it simply requires seeking a solution with a time-dependent length scale.
- That is exactly what we are going to do here.
- We are going to seek a solution to Einstein's equations averaged over many galaxies in which space ***and time*** are scaled by a single time-dependent length scale, $\delta(t)$.
- We will find one that appears to agree remarkably well with the data.
- And even our `predictions' from a year ago seem to forecast what JWST is seeing now.

Hubble `Deep Space' Photo



These are all galaxies!!! Millions of them averaged together are our '***fluid particles'--so we treat this like a Reynolds-averaged continuum.***'

Velocities approach the speed of light – so we need General Relativity

- **What assumptions should we make from the observations?**

- **Flat. No curvature**. So basically reference frame should be **Minkowski.**
- **Homogeneous in an infinite space**. **Space NOT growing, but things are flying apart.**
- **Initial value problem with the Big Bang simultaneously everywhere.**
- **Atomic clocks** should work in at least one frame of reference, ***but maybe not in other.***
- The **BIG new ideas:**
- **Let time and space coordinates evolve together in our "physical" or gravitational frame where things fly by us.**
- And **demand that nothing be moving at all in our `atomic clock' space. Like Lagrangian (or material) coordinates in Fluid Mechanics.**

- We use Einstein’s Field Equations (μ,ν = 0,1,2 or 3) in the following form:

$$R^{\mu\nu} = \frac{8\pi G}{c^4} \left[T^{\mu\nu} - \frac{1}{2} T \, g^{\mu\nu} \right]$$

- **- $R^{\mu\nu}$** is the **Ricci tensor** and **R** is the **Ricci scalar**, both defined from the **Riemann tensor $R^{\mu}{}_{\nu\alpha\beta}$**

  - $g^{\mu\nu}$ is the **metric tensor** which describes the space we have chosen to work in.

  -$T^{\mu\nu}$ is the **Einstein’s `stress-energy’ tensor** which `describes how matter deforms space’.

  - Note that we allow **$T^{\mu\nu}$** to have a ***non-zero divergence*** since we expect a source at t = 0 (the Big Bang).

Our two spaces $(\tau, \vec{\eta})$ and $(t, \vec{x})$

$(\tau, \vec{\eta})$ **-space is presumed to be Minkowski and fixed in the expanding matter. So its metric tensor is**

$$g_{\mu\nu} = [-1, 1, 1, 1]$$

$(t, \vec{x})$ **-space is presumed to be our physical space in which matter is expanding.**

We scale BOTH *physical* space AND time with a single length scale, δ, as follows:

$$\vec{\eta} \;=\; \frac{\vec{x}}{\delta(t)} \qquad\qquad \tau \;=\; c\int_{t_1}^{t} \frac{dt'}{\delta(t')}$$

τ **can be shown to be the `proper time'**

The metric tensors in physical space look like this:

$$g_{\mu'\nu'} = \frac{1}{\delta^2} \left\{ \begin{array}{cccc} -1 + (\dot{\delta}/c\delta)^2[x^2+y^2+z^2] & -(\dot{\delta}/c\delta)x & -(\dot{\delta}/c\delta)y & -(\dot{\delta}/c\delta)z \\ -(\dot{\delta}/c\delta)x & 1 & 0 & 0 \\ -(\dot{\delta}/c\delta)y & 0 & 1 & 0 \\ -(\dot{\delta}/c\delta)z & 0 & 0 & 1 \end{array} \right\} , \quad (10)$$

where $\dot{\delta} = d\delta/dt$. The determinant is $g = -1/\delta^8$.

The corresponding contravariant metric tensor in physical space, $g^{\mu'\nu'}$, is readily computed to be:

$$g^{\mu'\nu'} = \delta^2 \left\{ \begin{array}{cccc} -1 & -(\dot{\delta}/c\delta)x & -(\dot{\delta}/c\delta)y & -(\dot{\delta}/c\delta)z \\ -(\dot{\delta}/c\delta)x & 1 - (\dot{\delta}/c\delta)^2x^2 & -(\dot{\delta}/c\delta)^2xy & -(\dot{\delta}/c\delta)^2xz \\ -(\dot{\delta}/c\delta)y & -(\dot{\delta}/c\delta)^2xy & 1 - (\dot{\delta}/c\delta)^2y^2 & -(\dot{\delta}/c\delta)^2yz \\ -(\dot{\delta}/c\delta)z & -(\dot{\delta}/c\delta)^2xz & -(\dot{\delta}/c\delta)^2yz & 1 - (\dot{\delta}/c\delta)^2z^2 \end{array} \right\} \quad (11)$$

It's determinant is $1/g = -\delta^8$.

Principal Theoretical Results

- 1. **No critical density.** This a consequence of a zero Ricci

  tensor and the zero left-hand-side of Einstein's equation.

- 2. The geodesic equation implies that the length scale **$\delta(t) = c\ t$. Note that $\delta(t)$ is both the `similarity length scale' AND what we can see of an *infinite* universe.**
- 3. The Hubble parameter is easily deduced to be **$H(t) = V_r / d = 1/t$** where **t** is the age of the universe in `gravitational time'.
- 4. This implies that **$H(t) / H_o = 1 + z$** where **z** is the Red-shift parameter, **$H_o = H(t_o)$** and **t_o** is the present time (and age of universe)**.**
- 5. The energy density, **e**, is given by **$e(t) = c^4 / G\ \delta(t)^2 = c^2 / G\ t^2$.**
- 6. The farther back we look, the more energy (or mass) we will find.

Relation of distance to star, D, and time at star, t_s, to redshift parameter $z = (\lambda_o - \lambda_s)/\lambda_o$

$$\frac{t_s}{t_o} = \frac{1}{1+z} \qquad D = c\, t_o \left[\frac{z}{1+z}\right] = R_o \left[\frac{z}{1+z}\right]$$

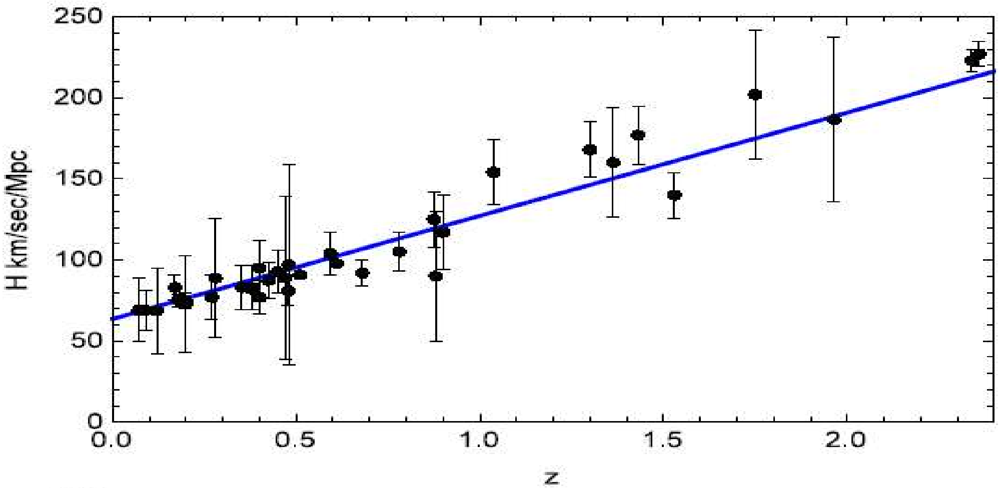
Our result that $D/R_o = z/(1+z)$ can be contrasted with the prevailing model given by [24] as:

$$\frac{D\ H_o}{c} = (1+z)\ |\Omega_k|^{-1/2}\ sinn\left\{|\Omega_k|^{1/2}\int_0^z [(1+z)^2(1+\Omega_M z) - z(2+z)\Omega_\Lambda]^{-1/2}\right\}$$

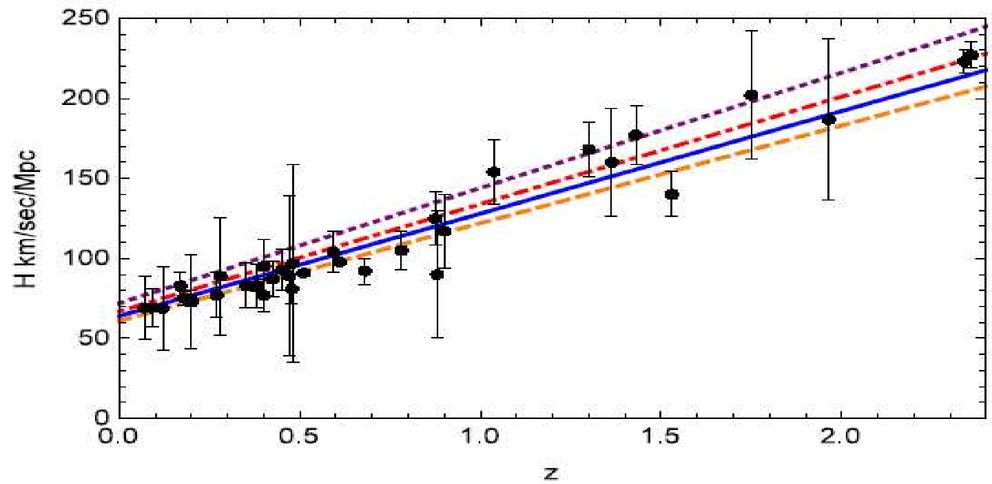
where $\Omega_k = 1 - \Omega_M - \Omega_\Lambda$, and *sinn* is sinh for $\Omega_k \geq 0$ and sin for $\Omega_k \leq 0$. The differences between the theories will prove to be crucial when we consider the supernovae data in Section 7.3 below.

Our Hubble prediction compared to Yu et al. data (2018)

$H(z) = H_o\,[1+z]$ where the redshift is **$z = (\lambda_o - \lambda_s) / \lambda_o$**



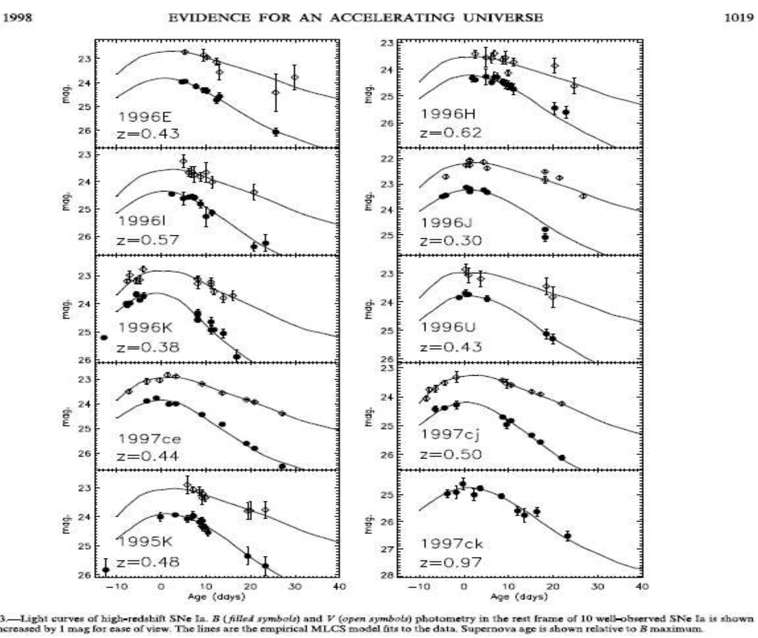
Best fit is **H_o = 63.6 km/s/Mpc**

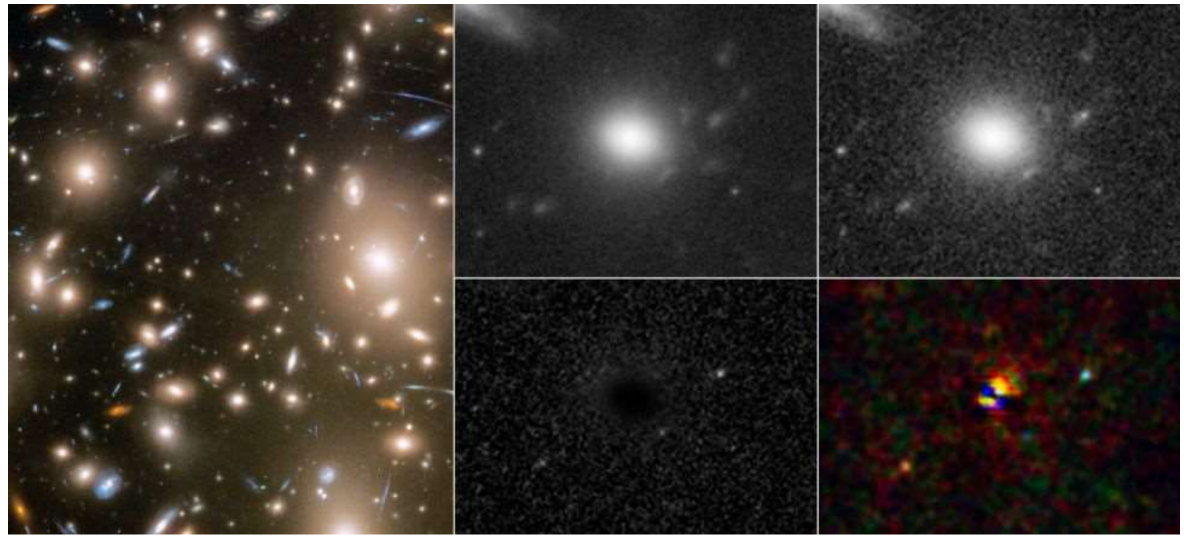


H_o = 61, 63.6, 67 and 71 km/s/Mpc

H_o = 63.6 km/s/Mpc implies **AGE of UNIVERSE = 15.4 billion years**.

What about supernovae (Type 1a) data that '*prove*' that expansion rate is increasing?





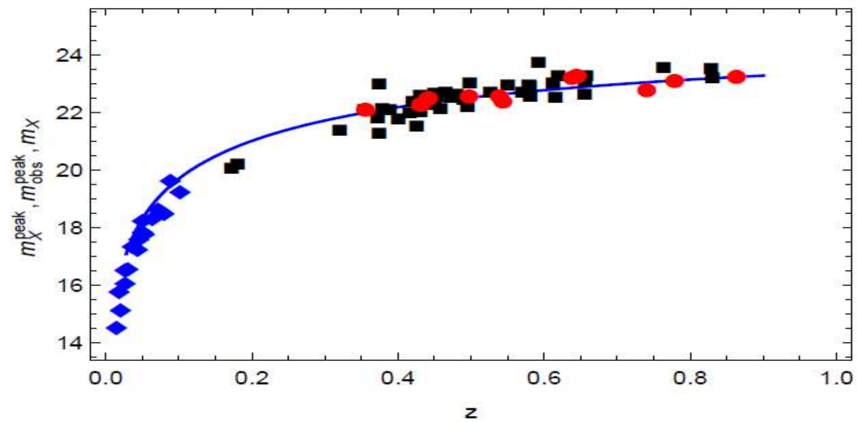
Abell 370 -gravitational lensing (left). Evolution (right).

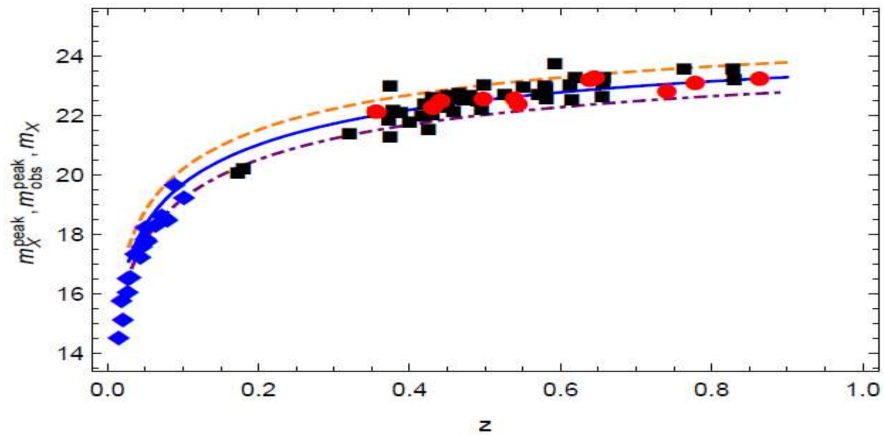
Reiss et al 1998 Supernovae

See animation at https://www.space.com/early-phase-supernovae-photographed-by-hubble

Our solution and “***uncorrected***” Supernovae data

$$\mu = m - M = -5\, log_{10}\left[\frac{z}{1+z}\right] \; - \; 5\, log_{10}\, [\frac{c}{H_o}] + 25 \qquad (90)$$





- **For plot on left, the only parameters are H_o= 63.6 km/s/Mpc (chosen from Hubble fit) and absolule magnitude M_v = 18.5 (close to Chandrasekar limit). Curve on right shows M_v = 18.0, 18.5, 19.0). All three are within the stated error bars.**
- **Our infinite universe is not expanding, but things are flying apart with an increasing length scale. And it needs no Dark Energy nor Dark Matter! No `1+z’ `correction’ to data needed either (see arguments why in paper).**

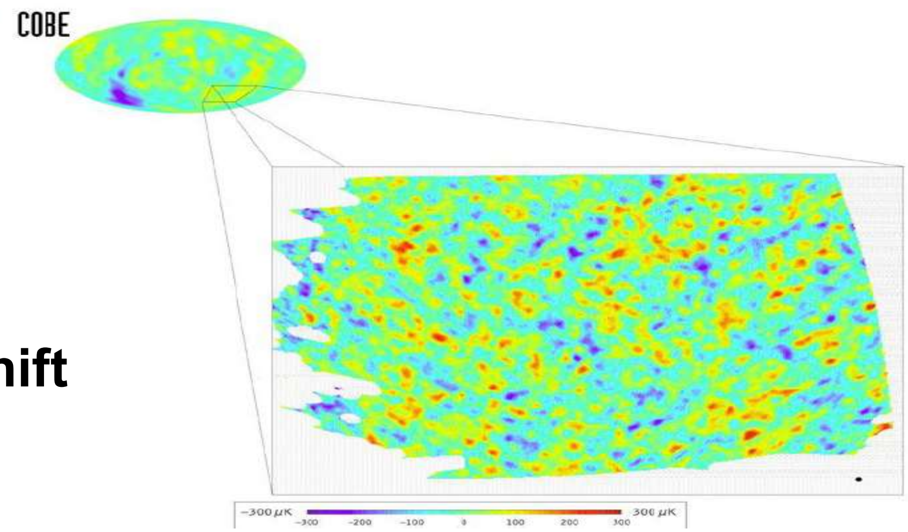
Cosmic Microwave Background Radiation

This what decaying turbulence looks like – not acoustic!

No way to have gotten rid of vorticity!

2/28/21, 10:38 AM Lecture 31: The Cosmic Microwave Background Radiation

- The Boomerang experiment (1999) mapped a smaller part of the sky than Cobe, but at much greater resolution.
- The typical anglar size of constant density regions is about 1 degree.
- Red = Hotter than average by 300 microKelvin.
- Blue = Cooler than average by 300 microKelvin.



From black body and redshift

$T_u(t_o)$ = 2.725 deg K

z = 1,100

$T_u(t)$ =3,000 deg K which is the temperature at which photons can propagate. But our theory places this at 14 billion years ago, and 1.4 billion years after Big Bang.

How about "The worst prediction in the history of physics"?

Our theory intersects with the QFT estimate at **t = 4.5 Planck times** using observed values of density (e.g. Abullah et al 2020) and Hubble parameter (Yu et al 2018)

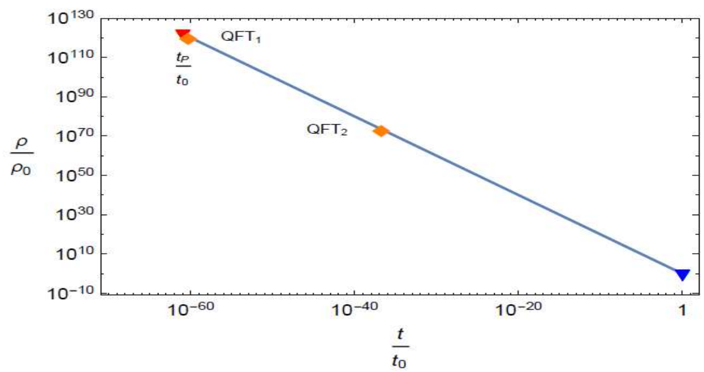


Figure 3: Plot of equation 98 showing 122 decades of mass density normalized by the present value versus time normalized by the age of the universe. The blue triangle is the present value. Also shown are the QFT1 value and the QFT2 value (orange diamonds), both normalized by the present day density of Abdullah et al. [2].

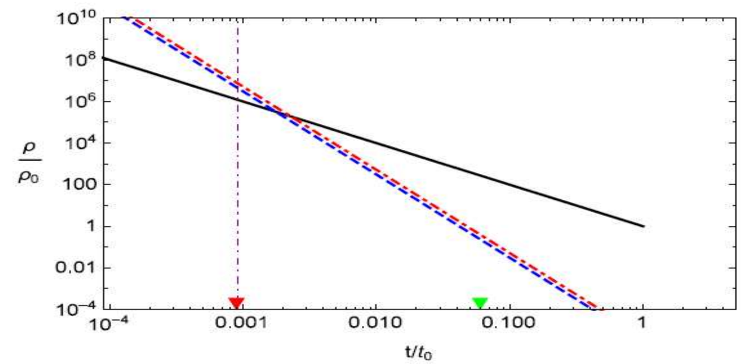
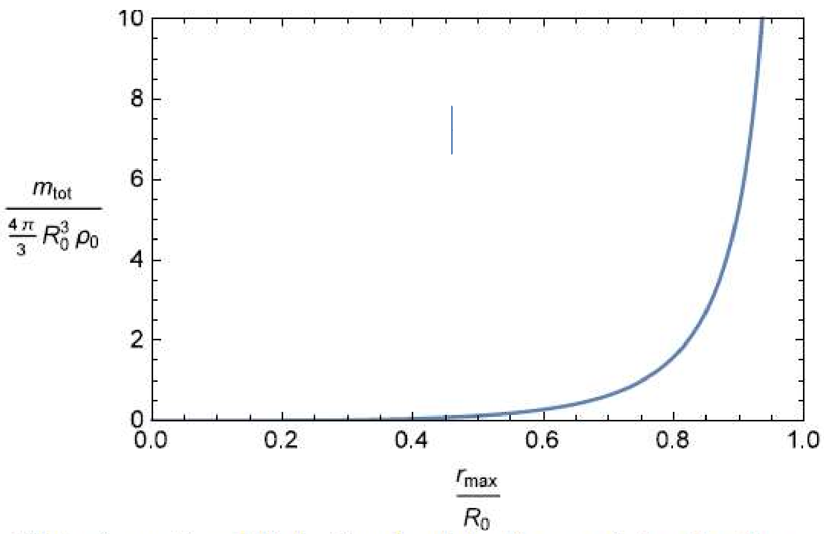


Figure 4: Blow-up of Figure 3 showing only times after $t/t_o = 10^{-4}$. The black line is equation 100, and the dashed lines are the radiation estimates of equation 109 and 110. For reference purposes, we have also shown on the plot the time associated with the Cosmic Background Radiation (red triangle) when the temperature was 3000 degrees K corresponding to $z = 1100$. The green triangle indicates the age of the Methuselah star (14.5 billion years).

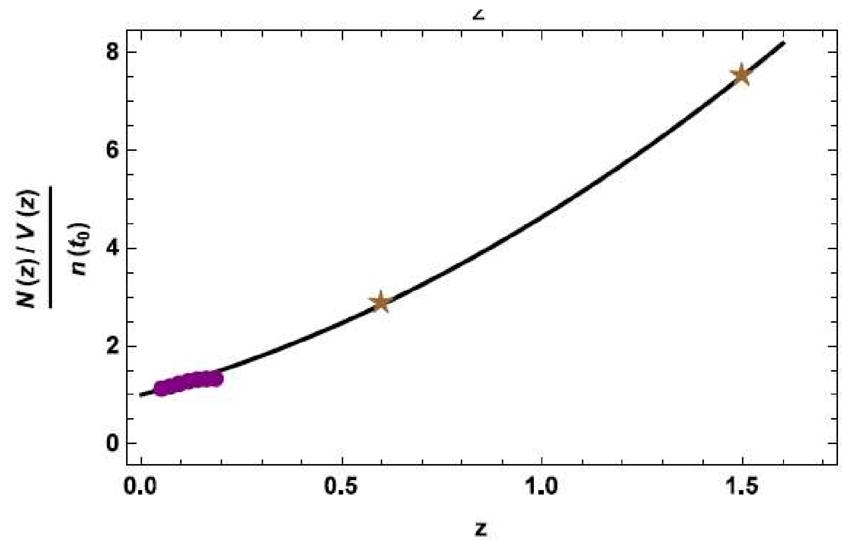
So Quantum Field Theory prediction might actually be the '***best prediction***'! Our theory consistent with both QFT and current measurements ***without dark matter or dark energy***. Only parameter is $\mathbf{H_o}$ from fit to Yu et al data

10 Tools for future work by astronomers



Plot of equation 120 looking back in time and showing how the cumulative mass varies with distance from an observer over which the integral is computed, r_{max}. The cumulative mass is normalized by the mass at present, $4\pi R_o^3 \rho_o$.

$$total\ mass \;=\; 4\pi R_o^2 \rho_o \int_0^{R_o[1-\epsilon]} \frac{r^2}{(R_o - r)^2} dr$$



Linear-linear plot of equation 141 and the cumulative cluster number data of Poggianti et al. [3] and Abdullah et al. [2]. For the latter we used $n(t_o) = 2250$.

$$\frac{N(z)/V(z)}{n(t_o)} = \left[\frac{1+z}{z}\right]^3 \left[-3z + \frac{3}{2}z^2 + 3\ln(1+z)\right]$$

Some interesting observations from our universe theory

- ***The baryonic matter astronomers say is out there now is all that is dynamically important***. We need neither Dark Matter nor Dark Energy.
- The stars do NOT vanish over the horizon, the visible horizon moves with them. But they may all burn out.
- The invariant of the stress-energy tensor, T is just proportional to:
- $T = \text{constant} \quad u(t)^3 / \delta(t)$
- Every turbulence expert immediately recognizes this from Kolmogorov theory for turbulence in the limit of infinite Reynolds number.
- ***It is, ϵ_K, the spectral flux of energy to smaller scales.***
- Does this correlate with the generation of dust or galaxies? New JWST observations?

- Our proposed new model of the universe allows both time and space coordinates to expand together.
- It appears to account for many of the anomalies without needing additional hypotheses about dark energy or dark matter.
- We appear to be in very good company...

"I believe that the times and distances which are to be used in the Einstein's general relativity are not the same as the times and distances which were to be provided by atomic clocks. There are good theoretical reasons for believing that that is so, and for the reason that the gravitational forces are getting weaker compared to electric forces as the world gets older." (Paul Dirac, Göttingen Interview, 1982 [1])

Paul Dirac interview with F. Hund

https://www.youtube.com/watch?v=H7mOU1Xu-yA