APS/DFD Indianapolis, IN November 2022 Abstract: T11.00005

A “dark-energy-free” turbulence similarity solution for an infinite expanding universe using Einstein’s field equations

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References

A copy of this presentation and supporting papers and materials can be downloaded from www.turbulence-online.com

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- Figure and equation numbers in this presentation refer directly to the April 11, 2022 paper by us entitled " "**An alternative cosmological model for an expanding universe**"
- http://www.turbulence-online.com/Publications/Purdue_April_2022_Paper.pdf
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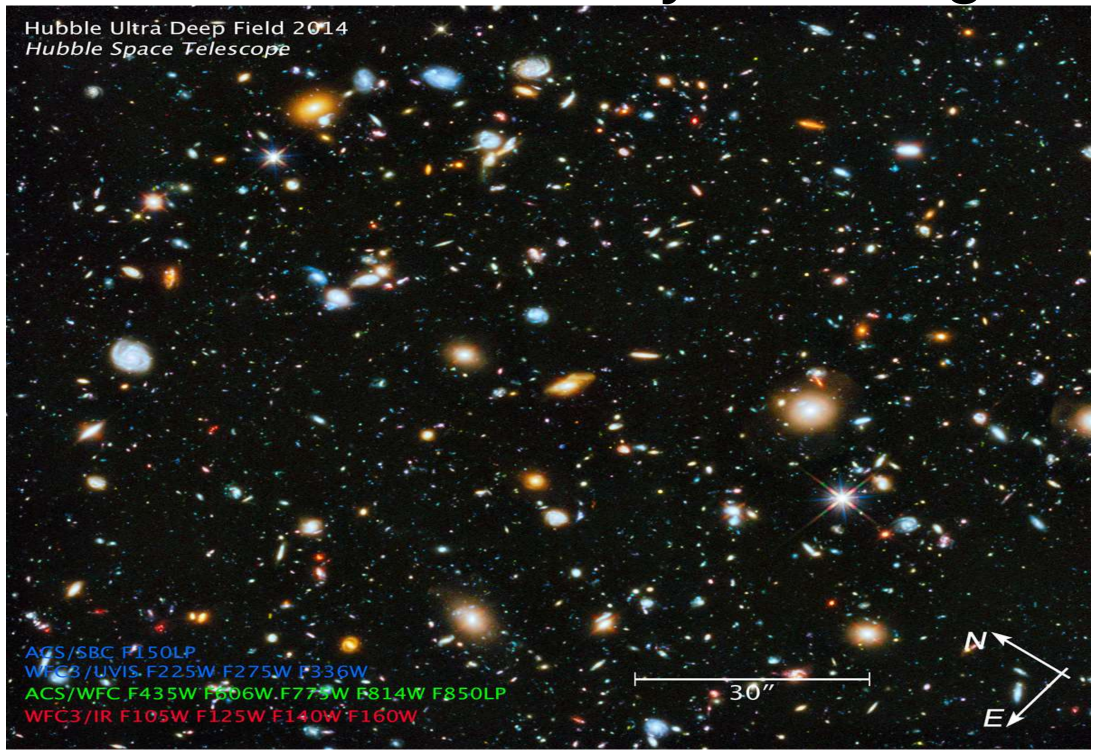
- Also of interest may be the longer presentation at Purdue on April 14:
- "***An alternative cosmological model for an expanding universe***

https://www.youtube.com/watch?v=E7rwrnkTVHQ

Hubble `Deep Space' Photo

These are not stars, they are all galaxies!!!



Millions of them averaged together are our '***fluid particles'***

--so we treat this like a continuum.'

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 the `standard' (*FLRW-based)* cosmological models to explain the data.**
- **But many 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!

A voice from the past…thanks to Howard Stone (Princeton)

"*I sat in on an applied math course taught by* **Phillip Saffman** (Cal Tech) *in the mid-1980s. In one lecture he did an example of asymptotics, I think related to a classic fluid dynamics problem (but that is not so important). He gave the general problem statement, made some assumptions, and went through the calculation on the board. At the end of the calculation, with the result clearly on the blackboard, a* ***student*** *raised their hand and asked something like*:

'Given the various assumptions, how do you know the result is OK?'

Saffman paused, looked at the class, and responded something like:

'Usually (often?) when the experiment is done it disagrees with prediction. … but then you understand the errors in your assumptions, and you can try again to then get the correct answer.' "

That is exactly what this talk is about --- TRYING AGAIN with NEW ASSUMPTIONS BASED ON 30 YEARS OF NEW DATA

How do we build a new theory?

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 idea: **Let time and space coordinates evolve together in our "physical" or gravitational frame.**
- And **demand that nothing be moving at all in one of our spaces. This is the real similarity assumption.**

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 chose 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:

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

τ can be shown to be the `proper time'

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. And the rest mass energy is given by **$\rho(t) = c^2 / G\ \delta(t)^2 = 1/ G\ t^2$.**

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

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

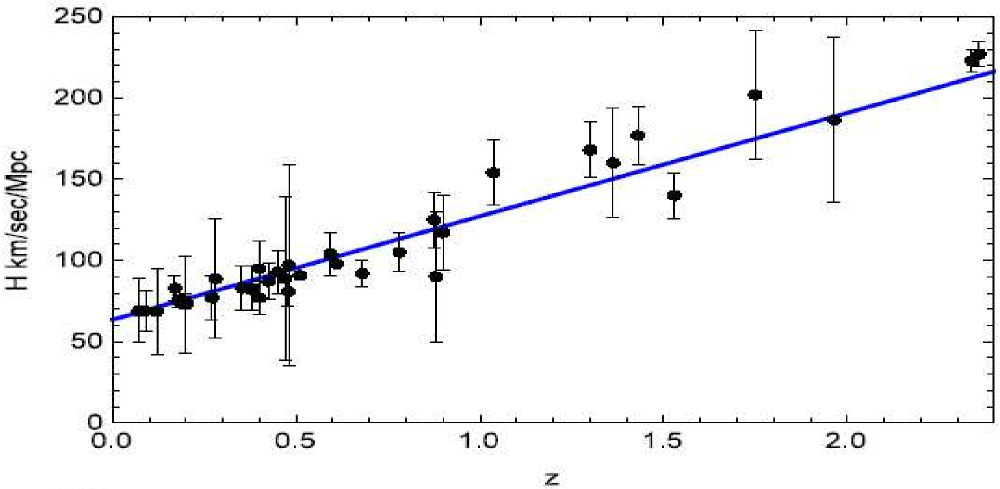
Our result that $D/R_o = z/(1+z)$ can be contrasted with the prevailing model given by [24] as:

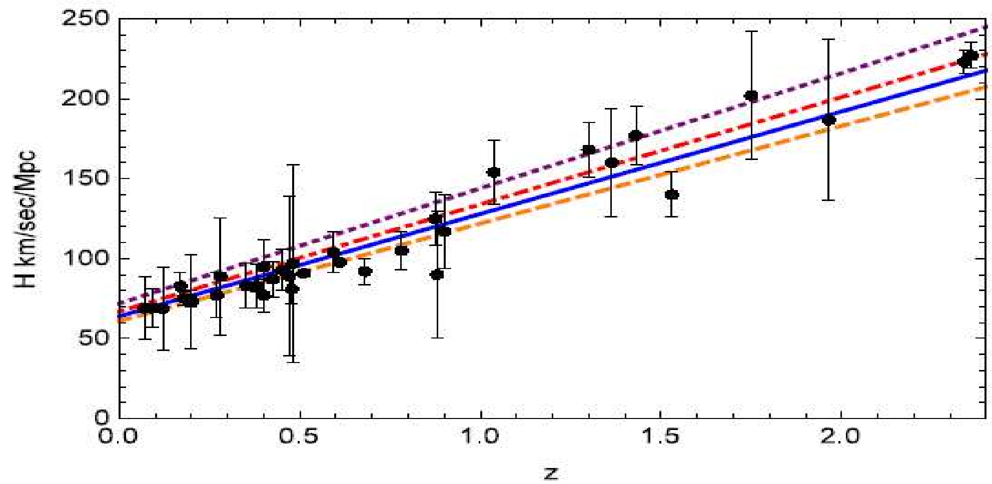
$$\frac{D\, H_o}{c} = (1+z)\, |\Omega_k|^{-1/2}\, sinn\left\{|\Omega_k|^{1/2} \int_0^z [(1+z)^2(1+\Omega_M z) - z(2+z)\Omega_\Lambda]^{-1/2}\right\}$$

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.

Hubble prediction compared to Yu et al. (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**.

Compare our single parameter, H_o, fit in the previous slide to

the standard model 3-parameter (H_o, Ω_{mo}, and Ω_{ro}) fit to same data .

Redshift parameter
$Z = (\lambda_o - \lambda_s) / \lambda_o$

The Hubble measurements (e.g. from Yu et al 2020) can be made to fit using standard theory **only by fitting parameters for dark energy and matter** to:

THE ASTROPHYSICAL JOURNAL, 856:3 (11pp), 2018 March 20 Yu, Ratra, & Wang

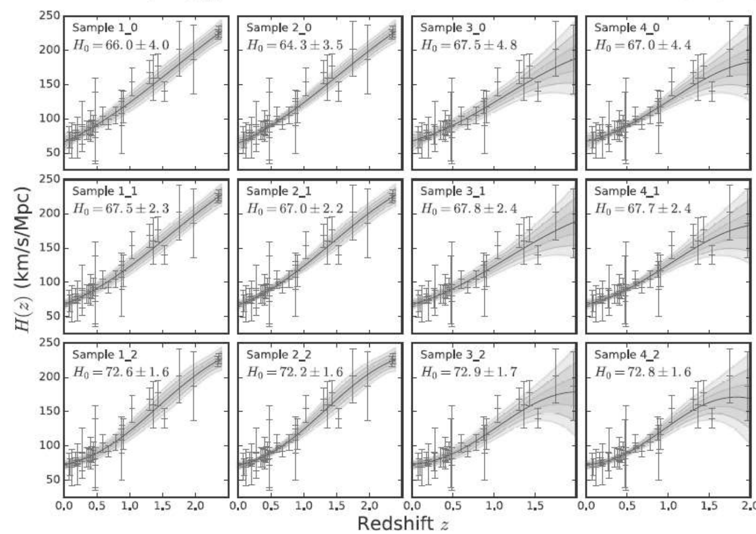


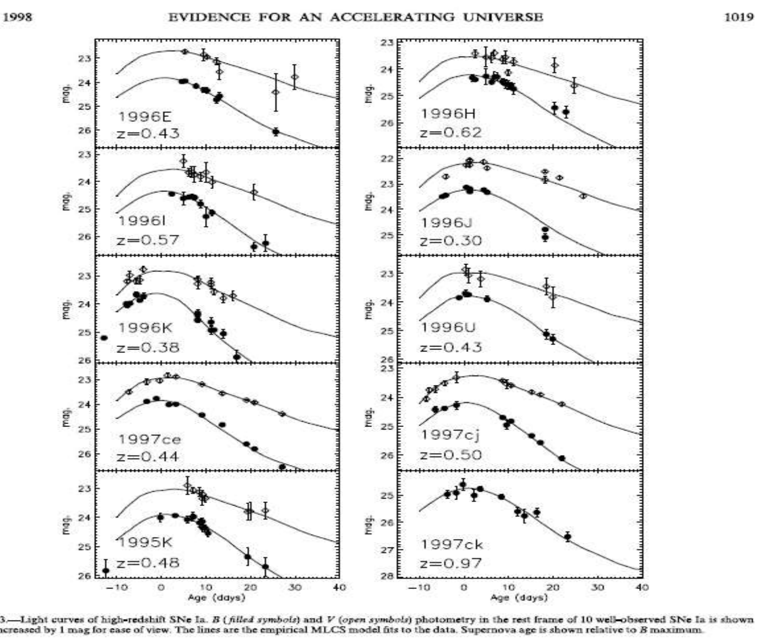
Figure 1. Smoothed $H(z)$ functions for all 12 samples. The blue lines are the mean curves and the shadow areas are 1σ, 2σ, and 3σ confidence regions.

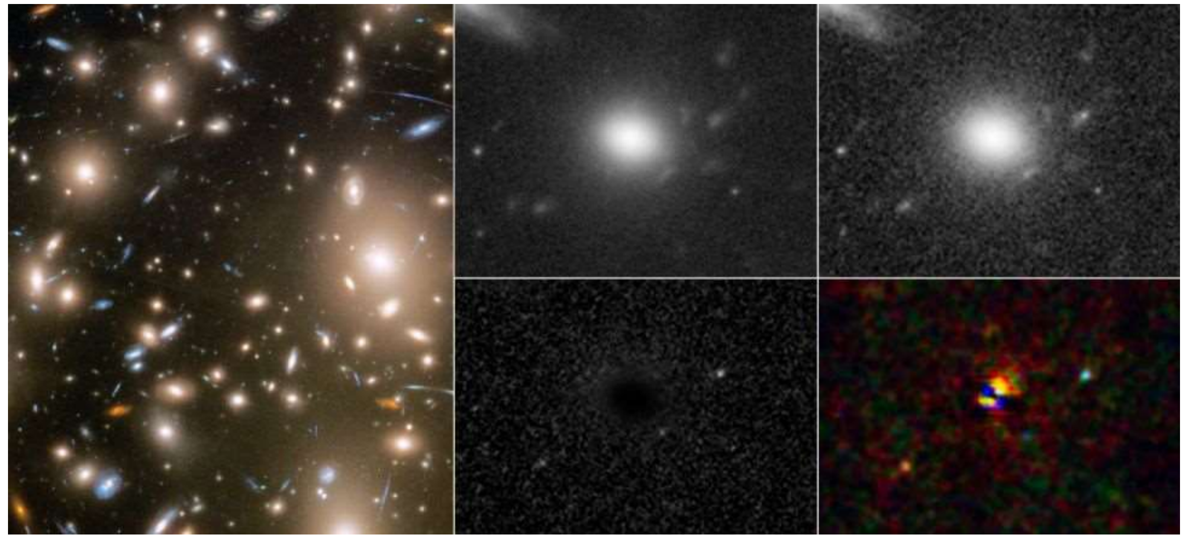
$$H(z) = H_o\sqrt{\Omega_{mo}(1+z)^3 + \Omega_{ro}(1+z)^4 + 1 - \Omega_{mo} - \Omega_{ro}} \qquad (77)$$

where Ω_{mo} and Ω_{ro} are the current values of the non-relativistic and relativistic matter density parameters.

Old best fit is **H_o = 67 km/s/Mpc** which implied **AGE of UNIVERSE = 13.8 billion years**.

What about supernovae (Type 1a) data that some have claimed 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

Figure showing relative magnitude, m_V, versus z from Perlmutter et al. 1989

Note the increases at the higher z Values and the increased need for Dark Energy to make the model fit.

$$m_B^{\text{eff}} \equiv m_R + \alpha(s-1) - K_{BR} - A_R$$
$$= \mathscr{M}_B + 5\log \mathscr{D}_L(z; \Omega_M, \Omega_\Lambda) ,$$

Also note that all data have been `corrected' by them by multiplying by 1+z.

Reis et al 1998 and Perlmutter et al 1999 were each awarded Nobel prizes for this work 'proving' that the universe was accelerating and the need for Dark Energy.

No. 2, 1999 Ω AND Λ FROM 42 HIGH-REDSHIFT SUPERNOVAE

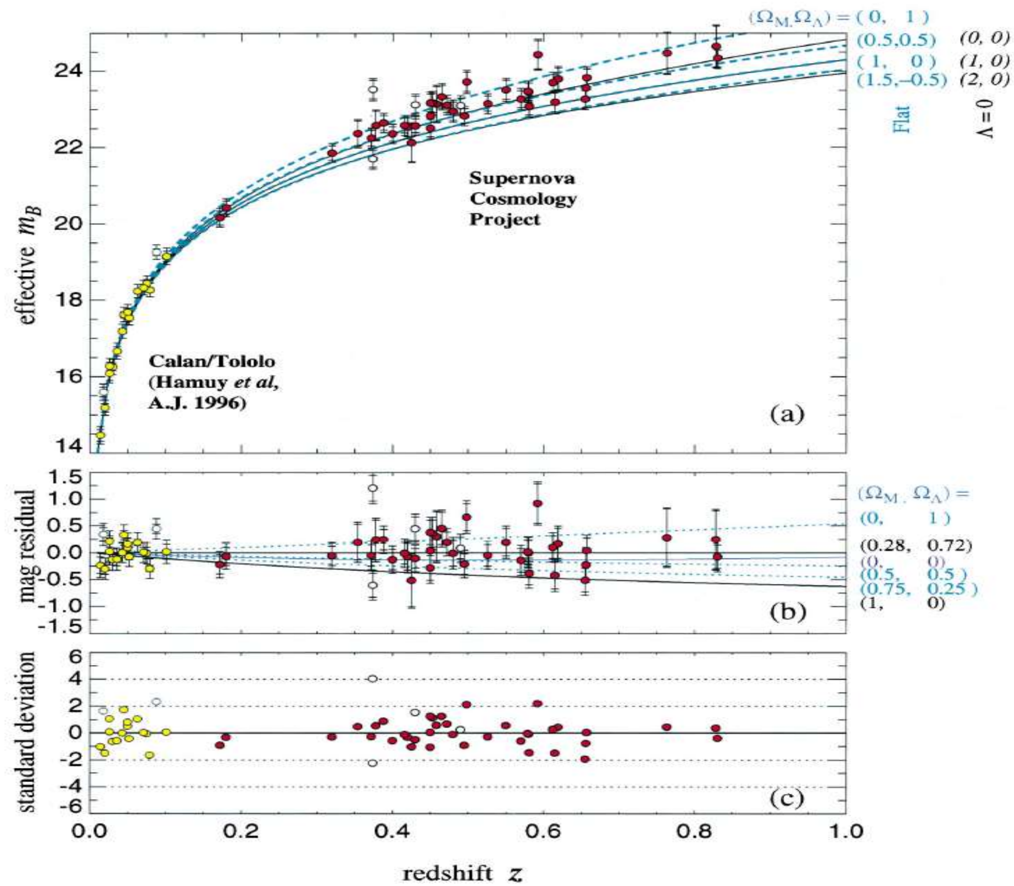
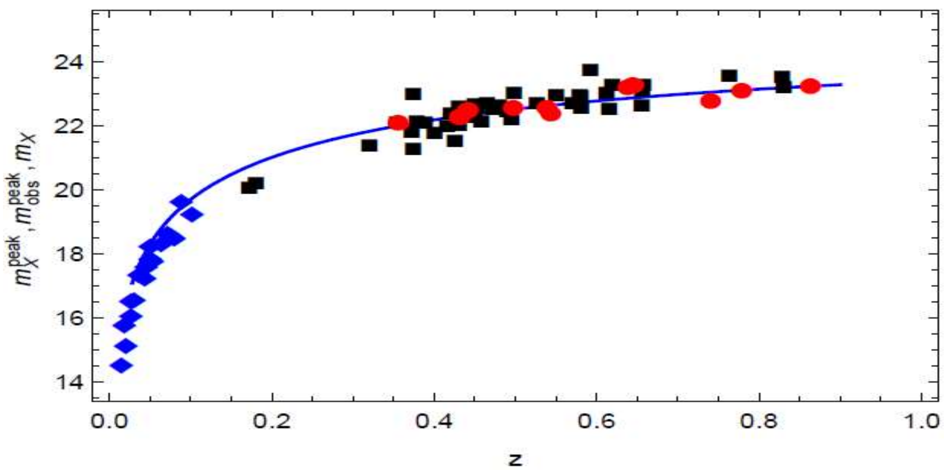
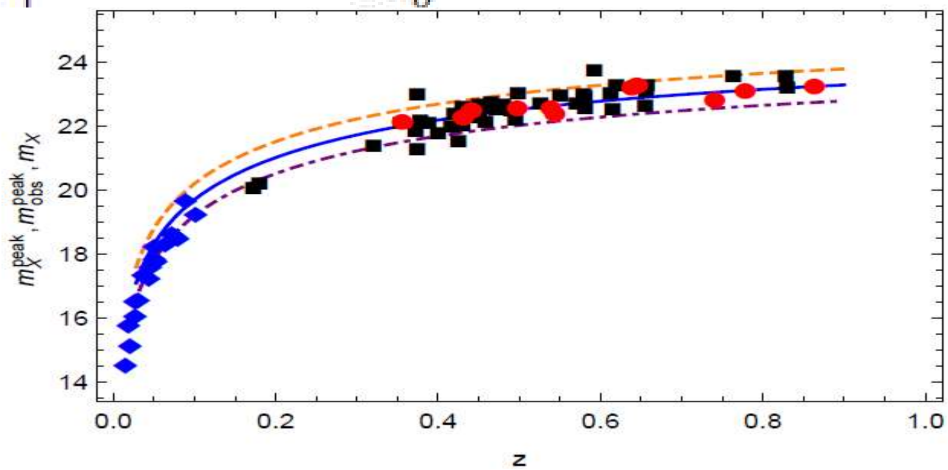


FIG. 2.—(a) Hubble diagram for 42 high-redshift type Ia supernovae from the Supernova Cosmology Project and 18 low-redshift type Ia supernovae fr the Calán/Tololo Supernova Survey, plotted on a linear redshift scale to display details at high redshift. The symbols and curves are as in Fig b) Magnitude residuals from the best-fit flat cosmology for the fit C supernova subset, $(\Omega_M, \Omega_\Lambda) = (0.28, 0.72)$. The dashed curves are for a range of cosmological models: $(\Omega_M, \Omega_\Lambda) = (0, 1)$ on top, (0.5, 0.5) third from bottom, (0.75, 0.25) second from bottom, and (1, 0) is the solid curve on bottom. middle solid curve is for $(\Omega_M, \Omega_\Lambda) = (0, 0)$. Note that this plot is practically identical to the magnitude residual plot for the best-fit unconstrained cosmol of fit C, with $(\Omega_M, \Omega_\Lambda) = (0.73, 1.32)$. (c) Uncertainty-normalized residuals from the best-fit flat cosmology for the fit C supernova subset, $(\Omega_M, \Omega_\Lambda$

Our solution compared to same `***uncorrected***' Supernovae data

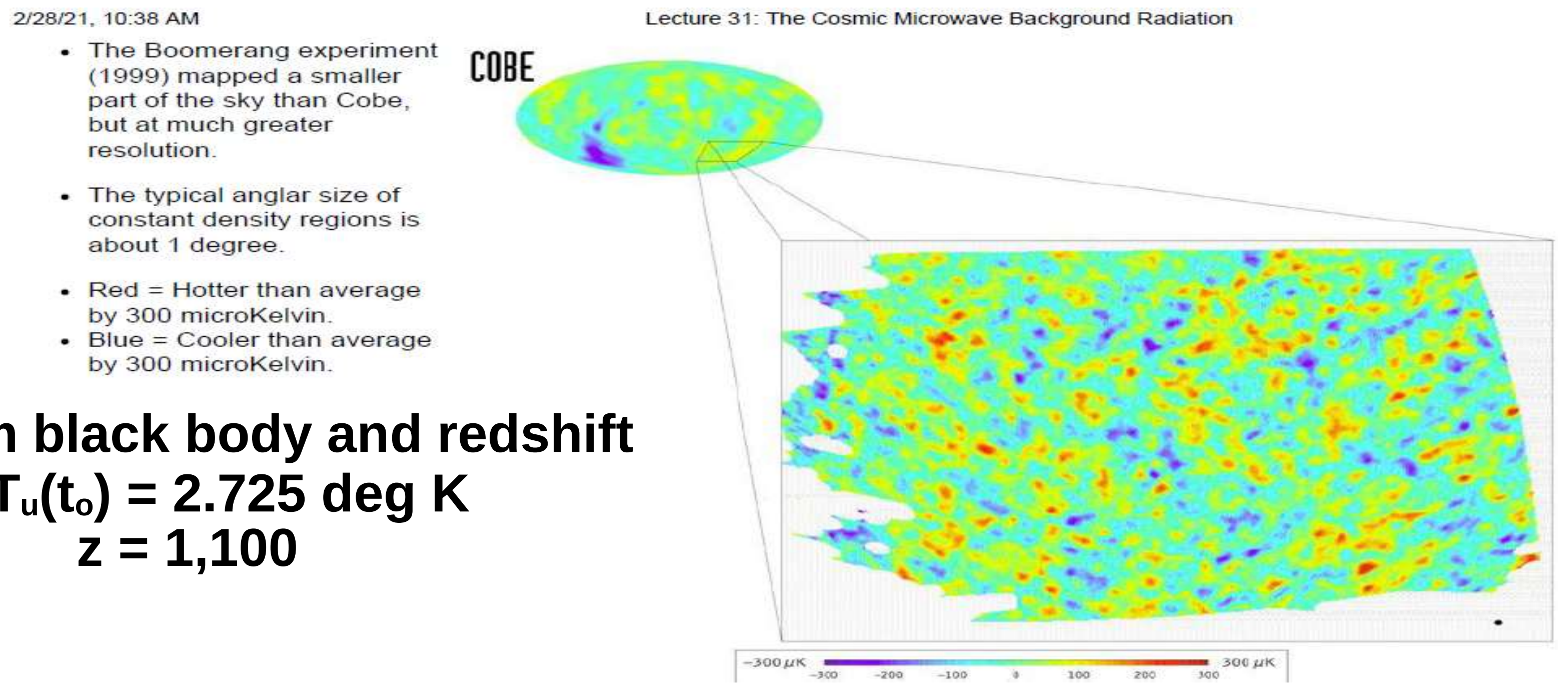
$$\mu = m - M = -5\ log_{10}\ \left[\frac{z}{1+z}\right]\ -\ 5\ log_{10}\ [\frac{c}{H_o}] + 25 \qquad (90)$$





- **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!)



From black body and redshift
$T_u(t_o)$ = 2.725 deg K
z = 1,100

- Beautiful slide illustrating CMBR – unfortunately I've lost the reference. :-(But to whoever made it, thank you.)

- **Our theory nails CMBR exactly looking backwards from the present….**

The average temperature is uniquely determined by the radiation spectral peak, say,

$$\lambda_m = b/T_u \tag{82}$$

where T_u is the absolute temperature of the universe and $b = 2.90 \times 10^{-3}$ m-K is the Wien's displacement constant.

But $\lambda_m(t) \propto \delta(t)$ so $\frac{T_u(t)}{T_u(t_o)} = \frac{\delta(t_o)}{\delta(t)} = \frac{t_0}{t} = 1 + z$

z = 1,100 corresponds exactly to $T_u(t_o)$ = 2.725 deg K and $T_u(t)$ =3,000 deg K which is the temperature at which photons can propagate.

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

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

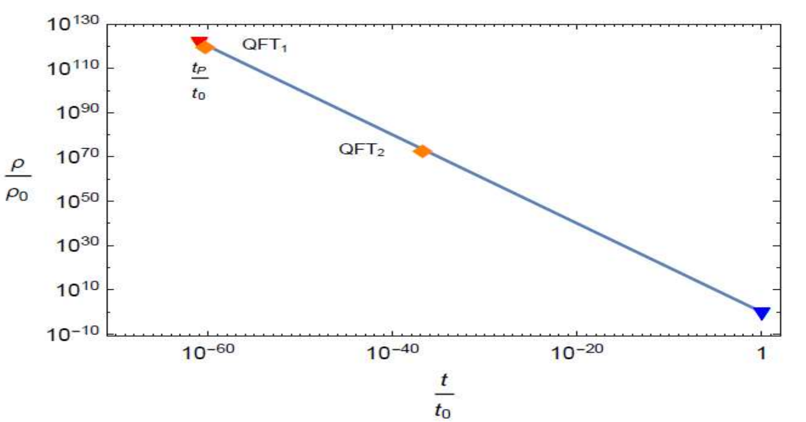


Figure 3: Plot of equation 98 showing 122 decades of mass density normalized by the present value versus time normalized by the age of the universe. The blue triangle is the present value. Also shown are the QFT1 value and the QFT2 value (orange diamonds), both normalized by the present day density of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

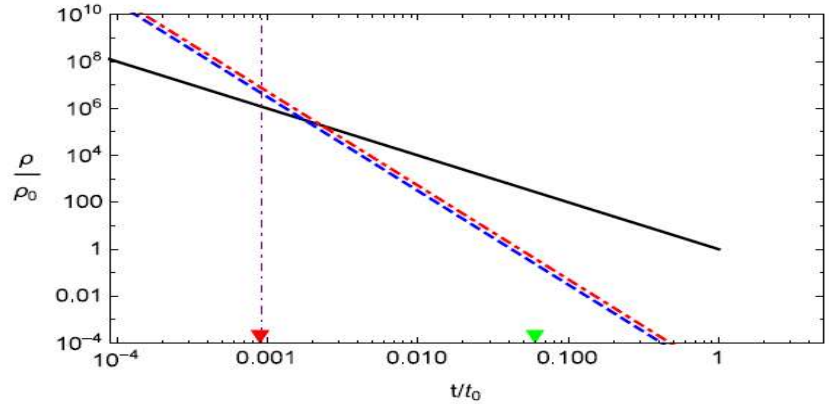


Figure 4: Blow-up of Figure 3 showing only times after $t/t_o = 10^{-4}$. The black line is equation 100, and the dashed lines are the radiation estimates of equation 109 and 110. For reference purposes, we have also shown on the plot the time associated with the Cosmic Background Radiation (red triangle) 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

Summary and Conclusions

- Our proposed new model of the universe allows both time and space coordinates to expand together.
- It appears to account for all of the anomalies without any 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