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Predicting Dark Energy Survey Results Using the Flat Space Cosmology Model

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Abstract

The Flat Space Cosmology (FSC) model is utilized to show how this model predicts the value of the Hubble parameter at each epoch of cosmic expansion. Specific attention in this paper is given to correlating the observable galactic redshifts since the beginning of the "cosmic dawn" reionization epoch. A graph of the log of the Hubble parameter as a function of redshift z is presented as the FSC prediction of the pending Dark Energy Survey results. In the process, it is discovered that the obvious tension between the SHOES local Hubble constant value and the 2018 Planck Survey and the 2018 Dark Energy Survey global Hubble constant values may be explained by a time-variable, scalar, Hubble parameter acting in accordance with the FSC model.

Keywords

Flat Space Cosmology, Dark Energy, Hubble Parameter, SHOES Hubble Constant, ΛCDM Concordance Model, Cosmology Theory, Early Universe

1. Introduction and Background

The SHOES (Supernovae, H_0, for the Equation of State of dark energy) report [1] of a "best estimate" local Hubble constant value of 73.24 ± 1.74 km·s^{-1}·Mpc^{-1} is in tension with the global Hubble constant estimates of 67.36 ± 0.54 km·s^{-1}·Mpc^{-1} and 67.77 ± 1.30 km·s^{-1}·Mpc^{-1} reported by the 2018 Planck Survey [2] and 2018 Dark Energy Survey (DES) [3] collaborations, respectively. Given these dramatically different results (at 3.4σ) between measurements of local and global values, one wonders if what most cosmologists prefer to call the Hubble *constant* is actually a time-variable, scalar, Hubble *parameter.* In the next few years, this question is likely to be resolved by earth and space-based telescopes and wide-field cameras in conjunction with 3D computer simulations of the time evolution of

our expanding universe. Ideally, we hope to learn the value of the Hubble parameter at each point in cosmic time beginning with the "cosmic dawn" epoch.

At present, the ΛCDM concordance model of cosmology is only seriously challenged by one other type of model, the $R_h = ct$ model. This type of model was introduced by Fulvio Melia in 2012 [4] and several similar models of this type soon followed. Perhaps the most successful of these models, in terms of observational correlations and predictions, is Flat Space Cosmology (FSC) [5] [6] [7] [8] [9]. The interested reader should start with a recent FSC summary paper [10], which shows how its predictive capacity and falsifiability make it preferable in many ways to the ΛCDM concordance model. To date, none of the many *global* predictions of the time-varying FSC model parameters (Hubble parameter, radius, mass, energy, entropy, average temperature, temperature anisotropy, *etc.*) have been falsified. One of the important ways in which the FSC model is superior to the ΛCDM concordance model is in its *predictive* capacity with respect to calculating the value of the Hubble parameter at every second of cosmic evolution from the Planck-scale epoch. FSC since its inception in 2015, for instance, has predicted a current global Hubble parameter value of 66.893 km·s^{-1}·Mpc^{-1}, which fits the measured 2018 Planck and 2018 DES values given above. This FSC value also fits the 66.93 ± 0.62 km·s^{-1}·Mpc^{-1} value predicted by ΛCDM with 3 neutrino flavors having a mass of 0.06 eV.

It is the purpose of this paper to show how the FSC model, since its inception, has provided a means to calculate the Hubble parameter values correlating with every cosmic redshift epoch since "cosmic dawn".

2. Results

The relevant FSC equations useful for these calculations include:

$$z \cong \left(\frac{T_t^2}{T_o^2} - 1 \right)^{1/2} \tag{1}$$

$$T_t^2 R_t \cong 1.027246639815497 \times 10^{27} \, \text{K}^2 \cdot \text{m} \tag{2}$$

It is trivial to show how Equations (1) and (2), in conjunction with the FSC Hubble parameter definition ($H_t = c/R_t$), can be rearranged and undergo substitution to give:

$$T_0^2 \left(z^2 + 1 \right) \cong H_t \left[\frac{1.027246639815497 \times 10^{27} \, \text{K}^2 \cdot \text{m}}{c} \right] \tag{3}$$

For ease of comparison, the value of the time-dependent Hubble parameter H_t in reciprocal seconds (s^{-1}) can be multiplied by $3.08567758 \times 10^{19}$ km·Mpc^{-1} to convert H_t to its conventional km·s^{-1}·Mpc^{-1} units. To accomplish this, the left-hand term in (3) is multiplied by this factor. One can now use the following equation to compare redshift z values with H_t values in km·s^{-1}·Mpc^{-1}:

$$T_0^2 \left(z^2 + 1 \right) \left(3.08567758 \times 10^{19} \, \text{km} \cdot \text{Mpc}^{-1} \right)$$
$$\cong H_t \left[\frac{1.027246639815497 \times 10^{27} \, \text{K}^2 \cdot \text{m}}{c} \right] \tag{4}$$

Taking the square root of both sides of (4) gives:

$$\left(z^2+1\right)^{1/2} \cong \left[H_t\right]^{1/2} \left[\frac{1.027246639815497 \times 10^{27}\,\mathrm{K}^2 \cdot \mathrm{m}}{cT_0^2\left(3.08567758 \times 10^{19}\ \mathrm{km} \cdot \mathrm{Mpc}^{-1}\right)}\right]^{1/2} \tag{5}$$

Using the $z + 1$ convention for redshift, this approximates to:

$$z + 1 \cong 0.122\sqrt{H_t} \tag{6}$$

One can then use the knowledge that today's FSC Hubble parameter value of 66.893 km·s^{-1}·Mpc^{-1} corresponds to 14.617 billion years of current cosmic age in order to calculate Hubble parameters at every billion-year interval of cosmic age. The following equation is useful in this regard:

$$H_t \cong H_0\left(\frac{14.617}{t}\right) \tag{7}$$

where the t value is simply the integer, or fractional number, of billions of years of cosmic age, and $H_0 = 66.893$ km·s^{-1}·Mpc^{-1}.

One can then construct the following table (**Table 1**) of FSC Hubble parameter values corresponding to redshift z values varying from $z = 0$ (corresponding to today's observed global Hubble parameter value) to $z = 11.09$ (for the epoch of the highest-redshift galaxy yet observed).

Table 1. Cosmic age, redshift z, Hubble parameter, Log$_{10}$ Hubble parameter.

Cosmic Age (Gyrs)	Redshift z	H_t (km·s^{-1}·Mpc^{-1})	Log$_{10}(H_t)$
14.617	0.00	66.893	1.83
14	0.02	69.84	1.84
13	0.06	75.21	1.88
12	0.10	81.48	1.91
11	0.15	88.89	1.95
10	0.21	97.78	1.99
9	0.27	108.64	2.04
8	0.35	122.22	2.09
7	0.44	139.68	2.15
6	0.56	162.96	2.21
5	0.71	195.55	2.29
4	0.91	244.44	2.39
3	1.20	325.92	2.51
2	1.70	488.89	2.69
1	2.81	977.77	2.99
0.5	4.40	1955.55	3.29
0.25	6.63	3911.1	3.59
0.142	9.11	6868.25	3.84
0.0996	11.09	9820.49	3.99

The results shown in **Table 1** can be used to present a graph (**Figure 1**) of $\log_{10}(H_t)$ as a function of redshift z.

3. Discussion

The FSC publication entitled, "Temperature Scaling in Flat Space Cosmology in Comparison to Standard Cosmology" [11] makes note of the fact that the temperature curves of FSC and ΛCDM cosmology are somewhat different, particularly in the first billion years or so of cosmic evolution. This is a function of the embedded FSC scaling thermodynamic equation. A graph (**Figure 2**) from the temperature scaling paper is reproduced herein.

The blue line is the radiation temperature (T_R) curve expected in the ΛCDM concordance model and the green line is the radiation temperature curve expected in FSC. The dashed red line represents the measured and projected spin temperature (T_S) and the solid red line represents the baryonic gas temperature
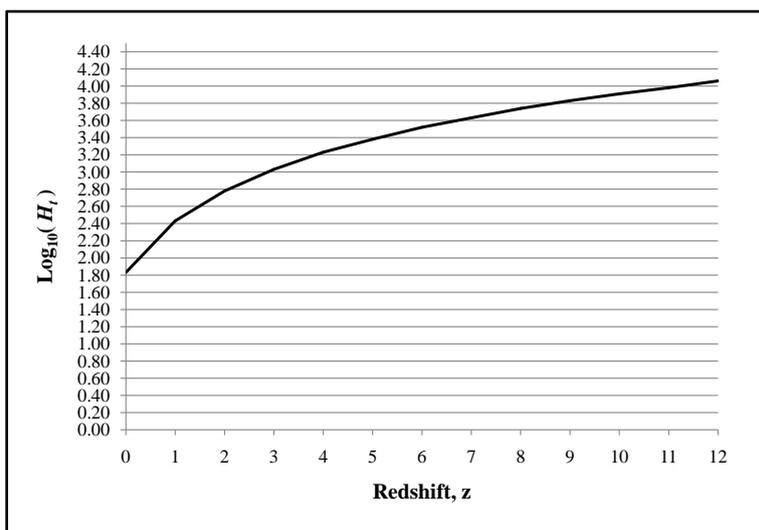

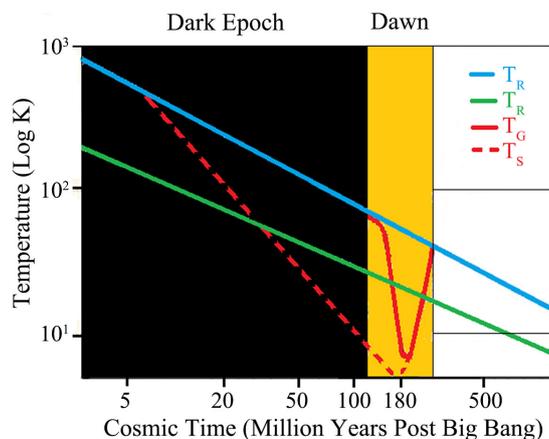**Figure 1.** $\log_{10}(H_t)$ as a function of redshift z.

Figure 2. Cosmic temperature vs cosmic age in ΛCDM (blue) and FSC (red).

(T_G). In Figure 2, the concordance model temperature curve, as well as the concordance model conception of the time scale at which "cosmic dawn" occurred is presented as seen in Bowman's publication [12] on the recent redshifted 21-cm observations. One should note that, in the FSC model, the same radiation temperatures and redshift z values correlating to "cosmic dawn" occurred at about 20 - 60 million years after the Planck epoch, as opposed to approximately 110 - 250 million years in the concordance model. As discussed in recent FSC papers (see references [10] and [11]), the FSC model allows for earlier galaxy formation by several hundred million years in comparison to the concordance model. Thus, the FSC model, by its significantly *colder* temperature curve in the first billion years, offers a solution to the "The Impossibly Early Galaxy Problem" described by Steinhardt [13].

Of most importance with respect to the stated purpose of this paper, one can now see that the FSC model makes very specific predictions for the Hubble parameter values correlating with the range of currently observable galactic redshifts. The following major points need to be stressed:

1) As is true for all $R_h = ct$ models, the FSC Hubble parameter is *scalar* over the great span of cosmic time. $R_h = ct$ models require that the Hubble parameter value be defined according to $H_t = c/R_t$, where c is the speed of light and R_t is the Hubble radius at any time t. Thus, while at any point in human time spans the Hubble parameter may appear to be a constant, any cosmic model which incorporates c/R_t within its Hubble parameter equation *stipulates* that the Hubble term is not a true constant over the great span of cosmic time.

2) The SHOES study of the "local" Hubble constant measured galactic separation velocities per megaparsec at earlier cosmic times corresponding to a range of redshift z values of less than 0.15. It is interesting to note that their averaged "outlier" Hubble constant value corresponds roughly with the FSC Hubble parameter value correlated to a redshift z value of 0.06 (see Table 1). Moreover, when the Milky Way was used as a sole anchor for these observations, the SHOES study H_0 value of 76.18 ± 2.37 km·s^{-1}·Mpc^{-1} can be seen to fit the middle of the $0 < z < 0.15$ range of our Figure 1 curve. The $\log_{10}(76.18)$ is 1.88. *This may be more readily apparent if one compares the first five entries in Table 1.* Similar adopted zero point measurements of Hubble parameters corresponding to higher z value ranges are fully expected by these authors to correlate with higher sections of Figure 1 curve. If so, then modern cosmologists will soon accept the idea of a time-variable, scalar, Hubble parameter.

3) Table 1 and Figure 1 show very specific *predictions* of the FSC model awaiting confirmation or refutation within the next few years of observations. If these observations prove that the Hubble parameter has a radically different temporal history than predicted herein, the FSC model and any similar $R_h = ct$ models would then be falsified. On the other hand, if observations in the next few years fit with Table 1 and Figure 1, the temporal behavior of dark energy would be better understood using the FSC model. In such case, the FSC model

might then become the new concordance model.

4. Summary and Conclusions

The heuristic FSC $R_h = ct$ cosmology model is utilized to evaluate the tension between the SHOES local Hubble constant value and the Planck Survey and Dark Energy Survey global values. The SHOES report looked at a specific redshift z range of $0 < z < 0.15$. Thus, the first approximately 11 billion years of the cosmic expansion history was not subjected to their analysis.

In the FSC model, the Hubble parameter is defined according to $H_t = c/R_t$. Therefore, the FSC Hubble parameter is time-variable and scalar according to Table 1 and Figure 1. The FSC model predicts that the middle of the range of $0 < z < 0.15$ should correlate with a Hubble parameter value of approximately 75 km·s^{-1}·Mpc^{-1}, which fits the SHOES Hubble constant determination of 76.18 ± 2.37 for the part of their study using the Milky Way as their anchor galaxy.

The authors predict that, in the next few years, similar measurements corresponding to higher z value ranges will correlate with higher sections of Figure 1 curve. If this proves to be the case, then modern cosmologists will have to accept that what is currently called a Hubble constant is actually a time-variable, scalar, Hubble parameter. Furthermore, such a result would likely establish FSC as the new concordance model.

Dedications and Acknowledgements

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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