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Data from Twenty-Three FRB's Confirm the Universe Is Static and Not Expanding

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Abstract

Fast Radio Bursts from far away galaxies have travelled through the IGM and provide a tool to study its composition. Presently there are 23 FRB's whose host galaxies have been identified and the redshift found. This gives us the opportunity to test Dispersion Measure versus redshift predictions made by two models. The Macquart relation for an expanding Universe and the New Tired Light relationship in a static universe. In New Tired Light, redshifts are produced when a photon is absorbed and re-emitted by the electrons in the IGM which recoil on both occasions. Some of the energy of the photon has been transferred to the kinetic energy of the recoiling electron. The photon has less energy, a lower frequency and a longer wavelength. It has been redshifted. Since dispersion is due to an interaction between radio signals and these same electrons one would expect a direct relationship between DM and redshift in the New Tired light model. The relation is $DM = (m_e c/2hr_e)\ln(1+z)$ and contains no adjustable parameters—just a combination of universal constants related to the electron and photon. Notice that the relation is independent of the electron number density n_e since a change in n_e affects both the *DM* and redshift equally. A graph of *DM* versus ln(1 + *z*) will be a straight line of gradient $(m_e c/2hr_e)$ and, using SI units, substituting for the constants gives $7.318 \times 10^{25}\ \mathrm{m}^{-2}$. Using the data from the 23 well localized FRB's, with the weighting of the *DM*'s for expansion removed (so that the data corresponds to a static universe), a graph of *DM* versus ln(1 + *z*) has a gradient of $6.7 \times 10^{25}\ \mathrm{m}^{-2}$—9% below the predicted $(m_e c/2hr_e)$. The Macquart relation involves highly processed data and adjustable parameters to allow for "dark energy" and "dark matter" (neither of which has yet been found) and can be reduced to *DM* = 850*z* (in units of $\mathrm{pc{\cdot}cm^{-3}}$). Using the data from this set of localized FRB's gives a trendline with gradient $1.10 \times 10^{3}\ \mathrm{pc{\cdot}cm^{-3}}$—almost 30% higher than that predicted in an expanding universe model. The FRB data clearly comes down in favour of a static universe rather than an expanding one. Combining the *DM-z* relationship for the 23 well localized FRB's, with the Hubble diagram, drawn using the NED-D compilation of redshift independent extragalactic distances, produces a value of "n_e" the mean electron number density of the IGM, of $n_e = 0.48\ \mathrm{m}^{-3}$ close to the value $n_e = 0.5\ \mathrm{m}^{-3}$, long since predicted by NTL.

Keywords

Redshift, Dispersion Measure, Fast Radio Bursts, FRB's, Tired Light, Static Universe, IGM

1. Introduction

Fast radio bursts consist of intense bursts of electromagnetic radiation in the radio band and last for a very short duration. They were first discovered in 2007 by Lorimer *et al.* [1]. Since then, literally hundreds have been found and importantly, the host galaxies of many have been located—placing the sources of the FRB's beyond our own galaxy. This underlies the importance of FRB's as they enable us to explore the material of the intervening intergalactic medium (IGM). The initial burst takes the form of a short radio pulse of duration a few milliseconds. As the photons travel across the IGM they suffer "dispersion" whereby photons of higher frequency arrive before those of lower ones due to their interaction with the 'free' electrons in the IGM [2]. The greater the distance of travel, the greater the delay and thus the greater level of dispersion. As a measure of this we have the "Dispersion Measure" (DM) and this can tell us much about the IGM. New Tired Light (NTL) is a theory by which redshifts and the CMBR can be explained in a static, non-expanding universe by an interaction between the photons of light and the electrons in the IGM [3]-[5]. In New Tired Light, photons of light from distant galaxies are repeatedly absorbed and re-emitted by the electrons in the IGM, which recoil on absorption and re-emission. Some of the energy of the incoming photon is transferred to the recoiling electron and so the energy of the "new" photon emitted has been reduced, its frequency has been reduced and its wavelength increased. The photon has been redshifted.

Since Dispersion Measure and New Tired Light are both the result of the photons interacting with the electrons in the intervening IGM we would expect a direct relationship between the two. When, in 2017, details FRB 150418 (the first FRB to have its host galaxy identified) were published [6], this author used the *DM* and the distance to the host galaxy to predict the electron number density of the intervening IGM. This was then used to predict the redshift of the host galaxy by applying NTL—giving a prediction in agreement with the observed value [4]. All this in a static, non-expanding universe. This author then realized that there was no need to know the electron number density as both *DM* and NTL's predicted value of redshift, *z*, rely upon "n_e"—and so it would cancel in the final equations of a relationship between the two. This left a direct relationship between *DM* and $\ln(1 + z)$ including nothing other than universal constants relating to the electron, photon energy and the speed of light (m_e, r_e h and c). However, with only one localized FRB at that time it was difficult to test the actual relationship. Additionally, doubt has been cast on whether the cited host galaxy really is the host galaxy of FRB 150418 [7]—we needed to wait for more data. A linear relationship between *DM* and "*z*" is predicted (for $z < 1$) in an expanding universe [8] [9] and this appears to be the one being tested by mainstream workers. We have two predictions of the relationship between *DM* and redshift. The Macquart relation for an expanding universe and the New Tired Light' relation for a static non-expanding universe. We now have twenty-three well localized FRB's and so it would seem an ideal time to test both predicted relationships head-to-head—NTL and a static universe versus the Big Bang and an expanding universe—and see which theory comes out on top.

2. The Intergalactic Medium

2.1. The History

Let us firstly correct some of the misunderstandings regarding the structure of the IGM. Historically, in order to explain an observed background of X-ray radiation, it was proposed that the IGM consisted of a hot, fully ionized plasma at approximately 50,000 K. This discounted any hope of tired light theories as there was no way a photon could interact with a "free" electron and continue in a straight line. Theories involving the Compton effect would scatter the photons and blur the image [10]. But then it was discovered that the background of X-ray radiation was not coming from the IGM at all, but from active galactic nuclei in the far distance behind the IGM [11]. There is now no evidence for a high temperature, fully ionized plasma in the IGM and yet this idea exists in the minds of many to this day! An investigation of the power spectrum of the unresolved 0.5 – 2 keV cosmic X-ray background (CXB) with deep *Chandra* 4-Msec (Ms) observations in the Chandra Deep Field South (CDFS) concluded, "*We do not find any direct evidence of the so-called 'warm hot intergalactic medium*'" [12].

We must ask the question, "just what does the IGM consist of?"

It is generally accepted that there will be "dust" in the IGM that has been sputtered out from galaxies and that these dust particles are positively charged due to high energy photons in the UV and Gamma ranges removing electrons by the photo electric effect. The dust particles will reach dynamic equilibrium at a constant electrical potential whereby the rate at which new electrons are released (due to the photo-electric effect) is equal to the rate of return (due to recombination). Several papers have been published on this [13] and the electrical potential of approximately 20 eV calculated. What these workers do not ask is, "What happens to the ejected electrons?"

Well, these electrons must occupy the spaces in the IGM between the dust particles and thus the IGM consists of a "dirty" plasma—a sea of electrons with the neutralizing protons "fixed" on dust particles.

It is known that electrons can crystallise into a Wigner—Seitz, BCC crystal lattice under certain conditions [14] [15]. These are:

- Very low temperatures,
- Very high electron densities,
- A sea of electrons with no protons.

In the IGM, with the protons held fixed on dust particles, the remaining electrons filling the voids will crystallise onto a BCC Wigner-Seitz crystal lattice—held in place by their mutual repulsion. Their electrical potential energy is greater than their kinetic energy and so they will perform SHM about their "fixed" positions on the crystal lattice. Any electron that can perform SHM can absorb and re-emit photons of electro-magnetic radiation.

2.2. Evidence from the Lab

Electrons arranging themselves in a regular pattern have been seen in the laboratory. Micron diameter spheres have been suspended in a neutral plasma but here the more mobile electrons collided with the spheres and gave them an overall negative charge. The negatively charged spheres arranged themselves into a regular pattern i.e., *"a two-dimensional non-quantum lattice forms through the Coulomb event of these spheres. Microgravity is thought to be required to observe a three-dimensional structure*" [16]. In the IGM dust particles will arrange themselves into a regular three-dimensional pattern as will the electrons.

In Chemistry we often think of the electrons in molecules in constant motion but this is not the case. In molecules, the outer electrons arrange themselves at the vertices of regular formations and stay there, as if held in place by their mutual repulsion (the Pauli Exclusion Principle has a lot to do with it here). The positioning of the electrons determines the molecular shape along with the bond angles [17].

3. New Tired Light

As photons traverse the IGM they are absorbed and re-emitted by the electrons held on their lattice positions. French [18] states "*the propagation of light through a medium* (*even a transparent one*) *involves a continual process of absorption of the incident light and its reemission as secondary radiation by the medium."* On absorption, the energy of the incoming photon has been transferred to the electron which oscillates in SHM since the energy of the photon is transferred to vibrational energy of the electron. After a short delay, the oscillating electron emits a "new" photon which moves forwards to be absorbed and re-emitted by the next electron. Feynmann [19] describes the transmission of light through a transparent medium simply as "*photons do nothing but go from one electron to another, and reflection and transmission are really the result of an electron picking up a photon, "scratching its head", so to speak, and emitting* *a new photon."* This is how photons in the radio and light both travel across the IGM—but here the electrons are not rigidly fixed and so recoil both on absorption and re-emission. Some of the initial energy of the incoming photon has been transferred to the recoiling electron and so the energy of the "new" photon is less than the original one. The frequency is less and the wavelength longer—it has been redshifted. Since the recoil takes place along the line of sight, as the electrons recoil about their lattice positions there is no change in direction of the photon and hence no "blurring" of the image. The Hubble law becomes "photons of light from a galaxy twice as far away, undergo twice as many interactions with the electrons in the IGM and experience twice the redshift".

The relationship between the redshift, z, and the distance, d, between the source and observer was first published in 2006 [3] [20] [21] and is given by:

$$z = \exp(Hd/c) - 1 \tag{1}$$

where c is the speed of light in a vacuum and H is the Hubble constant. In NTL, we already have the relationship for the Hubble constant in terms of the electron:

$$H = 2n_e hr_e / m_e \tag{2}$$

where h is the plank constant, r_e, the classical electron radius, m_e, the electron rest mass and n_e, the electron number density.

A mean electron number density of $n_e = 0.5\,\text{m}^{-3}$ gives a value of the Hubble constant of $H = 2.05 \times 10^{-18}$ or $H = 63\,\text{km}\cdot\text{s}^{-1}\cdot\text{Mpc}^{-1}$.

For ease this derivation is given in appendix A to this paper.

Dispersion Measure. *DM*

An FRB is a short, sharp burst of radio energy with all frequencies emitted at the same time. Radio telescopes detect the arrival of these signals in a range of frequency bands and what is observed is the arrival of the signals in a procession with each frequency arriving one after another. The lower the frequency, the slower the signal travels through the IGM and the later that frequency arrives at Earth. The time delay measured in milliseconds is given by:

$$delay, \Delta t = 4.15 \times 10^6 \left(f_{low}^{-2} - f_{high}^{-2} \right) DM \tag{3}$$

where f_{low} and f_{high} are the lower and higher frequencies respectively (measured in Mhz), DM is the Dispersion Measure (measured in pc·cm^{-3}) and the term 4.15 × 10^6 MHz^2·pc^{-1}·cm^3·s is the dispersion constant, $D\left(= e^2/2\pi mc\right)$.

By measuring the time delay between the arrival of the pulses of different frequencies from a source a distance, d, away we can determine a quantity known as the Dispersion Measure (DM_{obs}) and standard Physics tells us the relationship between DM_{obs} and the mean free electron number density (n_e) along the path followed by the signal. Technically the DM_{obs} is the "*integrated column density of free electrons between an observer and a* source" [22]. DM, n_e and the distance, d, are related by the formula (Equation (4)):

$$DM_{obs} = \int_0^d n_e \mathrm{d}l \tag{4}$$

where DM_{obs} is measured in pc·cm^{-3}, n_e is measured in cm^{-3} and distance, d, is measured in pc. In a static universe where "n_e" is an average and constant, this reduces to:

$$DM_{obs} = n_e d \tag{5}$$

FRB's are at cosmological distances and workers in this field use a distance l, weighted by the redshift [23]. Let DM_{cos} be the weighted dispersion measure and it is that which is cited in papers as the extragalactic DM. We want DM_{obs} which is the dispersion measure without any weighting for expansion ie the dispersion measure in a static universe.

Eg.

$$DM_{cos} = \int_0^d \frac{n_e}{1+z} \mathrm{d}l \tag{6}$$

Note that in an expanding universe, at $z = 0$ in the interstellar medium Equation (6) reduces to Equation (4). If "n_e" is taken constant, in an expanding universe, this reduces to:

$$DM_{cos} = n_e d/(1+z) \tag{7}$$

Leading to the relationship:

$$DM_{obs} = n_e d = (1+z) DM_{cos} \tag{8}$$

In other words, to remove the weighting introduced to allow for "expansion" we must multiply the quoted values of DM_{cos} by $(1 + z)$ to give the dispersion measure, DM_{obs} in a non-expanding or static universe.

4. The *DM*-*z* Relationship Due to NTL

Making d, the subject in Equation (1) gives:

$$d = (c/H)\ln(1+z) \tag{9}$$

Equation (2) gives the Hubble constant in terms of the electron parameters and the mean free electron density, n_e. Substituting in Equation (6) gives:

$$d = (m_e c/2 n_e h r_e)\ln(1+z) \tag{10}$$

Equating Equations (5) and (10) for d gives.

$$DM_{obs}/n_e = (m_e c/2 n_e h r_e)\ln(1+z) \tag{11}$$

Notice, n_e, the mean free electron number density cancels and so for sparsely populated plasma the relation is independent of n_e. The reason being that the greater the electron number density, n_e, the greater the delay to the signal and hence the greater the DM. The greater the electron number density, n_e, the greater the number of photon—electron recoil interactions each photon will undergo, giving a greater redshift—(provided the plasma does not become so dense that the electrons are unable to recoil).

Simplifying:

$$DM_{obs} = \left(m_e c/2hr_e\right)\ln\left(1+z\right) \tag{12}$$

Thus, NTL predicts a relationship that can be tested. That is, a graph of DM versus ln(1 + *z*) is a straight line through the origin having a gradient of $\left(m_e c/2hr_e\right)$. Notice that there are no measured values or adjustable parameters in this relation—just a combination of known universal constants relating to the mass and radius of the electron, the Plank constant and speed of light both very much related to the photon (h, c) and the electron (m_e, r_e) in this, a photon-electron interaction in a static universe.

5. The Parsec and the Metre

Cosmologists prefer to work in their own unique units of distance—the parsec. In reality it is an artefact left over from the past. One reason given for the continued use of the parsec is, "*This peculiar form of units keeps the Physicists at a respectful distance to avoid contamination*" [24]. Some may say that it not only keeps the Physicists away but the whole of the rest of science. Since the parsec is based on the mean radius of the Earth's orbit it is not clear what is so special about this distance that it should be used for measuring distances throughout the entire Universe. Furthermore, it makes identifying the fingerprints of elementary particles in the observations (such as the photon and electron) difficult if one is using a different set of units than everyone else. Consequently (and as a Physicist) we will use SI units from now on.

Inserting SI values for m_e, c, h and r_e gives:

$$DM_{obs} = 7.318\times10^{25}\ln\left(1+z\right) \tag{13}$$

Notice that there are no variable parameters in this relationship, nor do we need to worry regarding dimming due to dust as the wavelength of the radio frequencies is far greater than the size of dust particles and diffraction effects take over.

The gradient of a graph of DM versus ln(1 + *z*) will be $7.318\times10^{25}\ \mathrm{m}^{-2}$—no matter what.

6. Testing the NTL Prediction

The Data

Whilst there have been many FRB's reported, few have had their host galaxy identified [23] and the redshift found. At the time of writing there are 23 FRB's with precise measurements of their DM and host galaxy redshift (plus one extra—a more recent discovery).

The DM_{cos} cited in papers is made up of contributions from the host galaxy, the Milky way galaxy (ISM) and its halo plus the IGM.

$$DM_{cos} = DM_{local} + DM_{EG} \tag{14}$$

With

$$DM_{local} = DM_{ISM} + DM_{halo} \tag{15}$$

And

$$DM_{EG} = DM_{IGM} + \frac{DM_{Host}}{1+z} \tag{16}$$

We must remember that the DM_{IGM} here is a cosmological DM and has been divided by the scale factor $(1 + z)$ in the papers.

For a list of FRB's used in this paper, see Table 1.

Table 1. List of FRB's with DM_{cos} and redshift of host galaxy and original.

Name	Redshift,z	$DM_{(cos)}$ (pc·cm^{-3})	Reference		
FRB121102	0.19273	557	Spitler *et al.*	(2016)	[25]
FRB180301	0.3304	534	Bhandari *et al.*	(2022)	[26]
FRB180916	0.0337	348.8	Marcote *et al.*	(2020)	[27]
FRB180924	0.3214	361.42	Bannister *et al.*	(2019)	[28]
FRB181030	0.0039	103.5	Bhardwaj *et al.*	(2021b)	[29]
FRB190102	0.291	363.6	Bhandari *et al.*	(2020)	[30]
FRB190523	0.66	760.8	Ravi *et al.*	(2019)	[31]
FRB190608	0.1178	338.7	Chittidi *et al.*	(2021)	[32]
FRB190611	0.378	321.4	Day *et al.*	(2020)	[33]
FRB190614	0.6	959.2	Law *et al.*	(2020)	[34]
FRB190711	0.522	593.1	Heintz *et al.*	(2020)	[35]
FRB190714	0.2365	504.13	Heintz *et al.*	(2020)	[35]
FRB191001	0.234	507.9	Heintz *et al.*	(2020)	[35]
FRB191228	0.2432	297.5	Bhandari *et al.*	(2022)	[35]
FRB200430	0.16	380.25	Heintz *et al.*	(2020)	[36]
FRB200906	0.3688	577.8	Bhandari *et al.*	(2022)	[35]
FRB201124	0.098	413.52	Fong *et al.*	(2021)	[37]
FRB210117	0.2145	730	James *et al.*	(2022)	[38]
FRB210320	0.2797	384.8	James *et al.*	(2022)	[38]
FRB210807	0.12927	251.9	James *et al.*	(2022)	[38]
FRB211127	0.0469	234.83	James *et al.*	(2022)	[38]
FRB211212	0.0715	206	James *et al.*	(2022)	[38]

Note that FRB181112 [39] which was included in the original list of data has been omitted since the signal passed through the halo of a foreground galaxy on its path to Earth. This halo made an unknown contribution to the DM and whilst estimates have been made, they are only that and so we omit this FRB from our study. Table 2 gives all the data for the above FRB's.

Table 2. List of FRB's along with the total DM contribution from the Milky Way galaxy plus halo and the contribution from the IGM.

Name	Redshift, z	$DM_{(cos)}$ (pc·cm^{-3})	$DM_{(MW)}$ (pc·cm^{-3})	$DM_{(IGM)}$ (pc·cm^{-3})
FRB121102	0.19273	557	188	369
FRB180301	0.3304	534	152	382
FRB180916	0.0337	348.8	200	148.8
FRB180924	0.3214	361.42	40.5	320.92
FRB181030	0.0039	103.5	41	62.5
FRB190102	0.291	363.6	57.3	306.3
FRB190523	0.66	760.8	37	723.8
FRB190608	0.1178	338.7	37.2	301.5
FRB190611	0.378	321.4	57.8	263.6
FRB190614	0.6	959.2	83.5	875.7
FRB190711	0.522	593.1	56.4	536.7
FRB190714	0.2365	504.13	38	466.13
FRB191001	0.234	507.9	44.7	463.2
FRB191228	0.2432	297.5	33	264.5
FRB200430	0.16	380.25	27	353.25
FRB200906	0.3688	577.8	36	541.8
FRB201124	0.098	413.52	123.2	290.32
FRB210117	0.2145	730	34.4	695.6
FRB210320	0.2797	384.8	42	342.8
FRB210807	0.12927	251.9	121.2	130.7
FRB211127	0.0469	234.83	42.5	192.33
FRB211212	0.0715	206	27.1	178.9

We now need to remove the weighting for redshift to obtain the "true" DM—that is, as it would be in a static Universe.

As an example of data processing to remove "expansion corrections" and return to the original data, let us look at FRB121102 since it is top of the list. The host galaxy has a redshift of $z = 0.19273$.

$$DM_{cos} = DM_{local} + DM_{EG} \tag{17}$$

The cosmologically weighted DM_{cos} is 557 pc·cm^{-3} and the contributions from our own galaxy and halo amount to 188 pc·cm^{-3} leaving a DM_{IGM} contribution of 369 pc·cm^{-3} for the IGM and host galaxy. Both of these have been "corrected" by dividing by $(1 + z)$ and so we must multiply 369 pc·cm^{-3} by $(1 + 0.19273)$ giving a "true" value of 440 pc·cm^{-3}. This is repeated for all other FRB's. Rather than guessing a value for the DM contribution of the host we will leave it in and our relation becomes:

$$DM_{true} = DM_{IGM} + DM_{host} \tag{18}$$

Repeating this for all FRB's and converting to SI units of m^{-2}. See **Table 3**.

Table 3. List of FRB's with DM_{true} in SI units of m^{-2} including the redshift of the host galaxy.

Name	z	DM_{true} /m^{-2}
FRB121102	0.19273	1.36E+25
FRB180301	0.3304	1.57E+25
FRB180916	0.0337	4.75E+24
FRB180924	0.3214	1.31E+25
FRB181030	0.0039	1.94E+24
FRB190102	0.291	1.22E+25
FRB190523	0.66	3.71E+25
FRB190608	0.1178	1.04E+25
FRB190611	0.378	1.12E+25
FRB190614	0.6	4.32E+25
FRB190711	0.522	2.52E+25
FRB190714	0.2365	1.78E+25
FRB191001	0.234	1.76E+25
FRB191228	0.2432	1.01E+25
FRB200430	0.16	1.26E+25
FRB200906	0.3688	2.29E+25
FRB201124	0.098	9.84E+24
FRB210117	0.2145	2.61E+25
FRB210320	0.2797	1.35E+25
FRB210807	0.12927	4.55E+24
FRB211127	0.0469	6.21E+24
FRB211212	0.0715	5.92E+24

Having removed the contribution from the Milky way and its halo we are left with DM_{true} and DM_{host} and so Equation (12) becomes:

$$DM_{true} = \left(m_e c/2hr_e\right)\ln\left(1+z\right) + DM_{host} \tag{19}$$

Or, substituting values for m_e, c, h and r_e we have:

$$DM_{true} = 7.318\times10^{25}\ln\left(1+z\right) + DM_{host} \tag{20}$$

Consequently, a graph of DM versus ln(1 + z) is predicted to be a straight line of gradient 7.318 × 10^{25} m^{-2} and an intercept comprising the mean DM_{host} contributions of the host galaxy. This is a firm prediction by NTL which is easily tested. See Figure 1.

We see that the graph of DM_{true} versus (1 + z) {blue dotted line} is a straight-line graph (R^2 = 0.74) of gradient 6.55 × 10^{25} m^{-2} and intercept 2.88 × 10^{24} m^{-2}—equivalent to a mean host galaxy contribution to the overall DM of 80 pc·cm^{-3}. This is in line with other workers who take the host contribution to the DM of 50 - 80 [38].

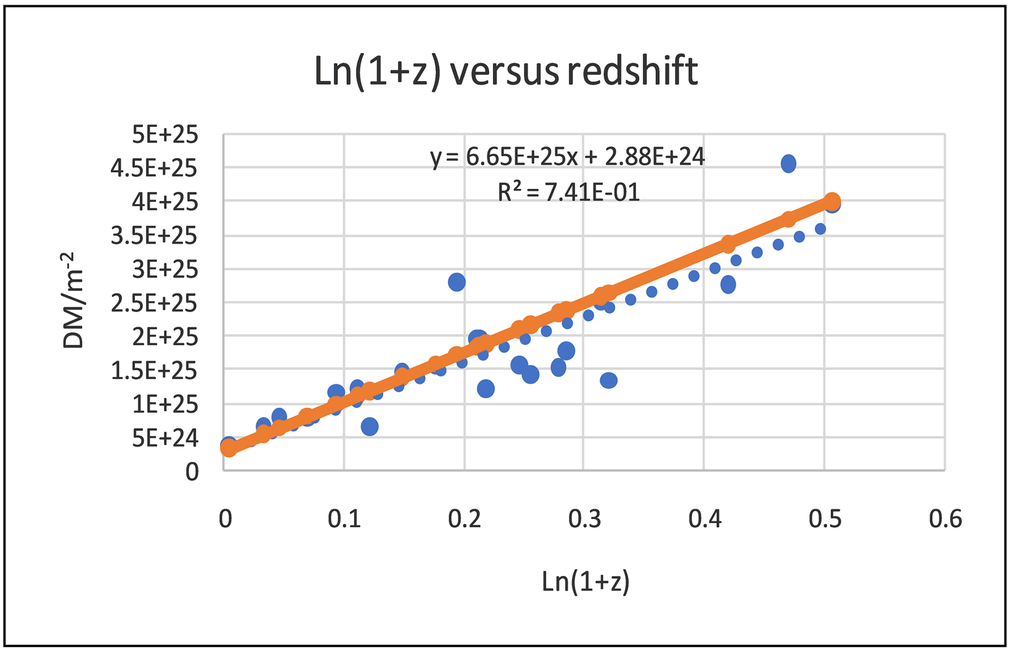

Figure 1. Graph of DM versus redshift with the weighting for redshift (ie expansion) removed from the DM values. The blue dotted line is the trendline for the data whilst the solid red line is that predicted by NTL.

The red line is the NTL predicted gradient of $\left(m_e c/2hr_e\right)$ with the same intercept for host galaxy as the trendline from the data.

Note that the gradient from observation (dotted blue) is a little less than that predicted of 7.318×10^{25} m^{-2}—a difference of just 9%. That is, the gradient is within 9% of the predicted value of $\left(m_e c/2hr_e\right)$—a combination of universal constants associated with the electron, the photon and speed of light. It is a remarkable coincidence if this is just by chance!

At the point of submission of this paper FRB20220610A was located with a host redshift of z = 1.016 (see Table 4) and since this FRB extends our graph greatly it would be remiss not to include it [40].

Table 4. DM (in SI units of m^{-2}) along with the redshift for FRB 20220610A.

FRB	z	$DM_{obs/}$ pc·cm^{-2}	$DM_{MW/}$ pc·cm^{-2}	DM_{obs} pc·cm^{-2}	ln(1 + z)	DM_{true} m^{-2}
20220610A	1.016	1457	81	1376	0.701	8.56×10^{26}

Including this data gives a negative intercept which is impossible in reality and is caused by any slight uncertainty in the large value of the DM being magnified and causing a larger shift in the intercept at $DM = 0$. Consequently, we will fix the intercept at 2.88×10^{24} m^{-2} (80 pc·cm^{-3}·pc) since this is found from the twenty-two FRB's at lower redshift and DM and presumably more accurate (see Figure 2).

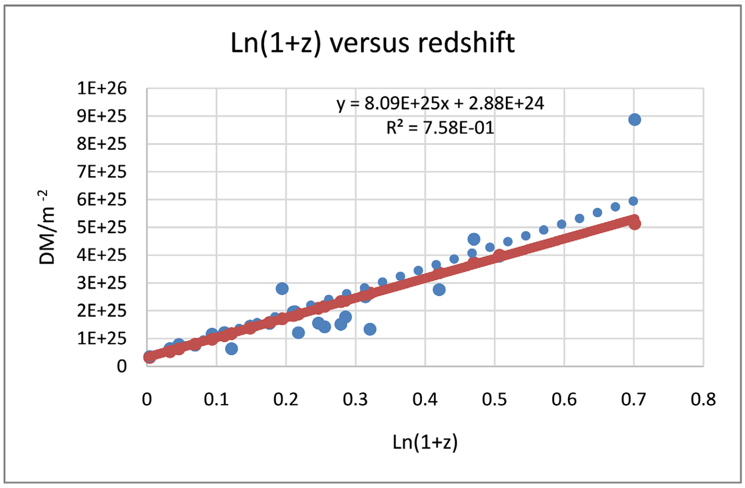

Figure 2. We see that the trend line (blue dotted) has a similar fit to the straight line with $R^2 = 0.79$ and the gradient of 8.09×10^{25} m^{-2}—a difference of just 11% above that predicted (red dashed line) of mc/2hr (7.318×10^{25} m^{-2}).

7. The Macquart Relation for *DM-z* in an Expanding Universe

Workers in this field applying the Big Bang and an expanding universe model apply the data to the Macquart Relation [41]. This is based on highly processed data involving "dark matter" which may or may not exist. The equation is given below and the symbols used are standard in the expansion model.

$$DM_{IGM} = \frac{3cH_0\Omega_b f_{IGM}}{8\pi G m_p} \times \int_0^z \frac{\left[\frac{3}{4}y_1\chi_e H(z) + \frac{1}{8}y_2\chi_e He(z)\right](1+z)\mathrm{d}z}{\left[\Omega_m (1+z)^3 + \Omega_\Lambda\right]^{1/2}} \tag{21}$$

Adopting nominal values of the parameters in this equation leads to a simpler relationship in the range $0 \le z \le 1$ of: [42] [43]

$$DM_{IGM} \cong 850z \tag{22}$$

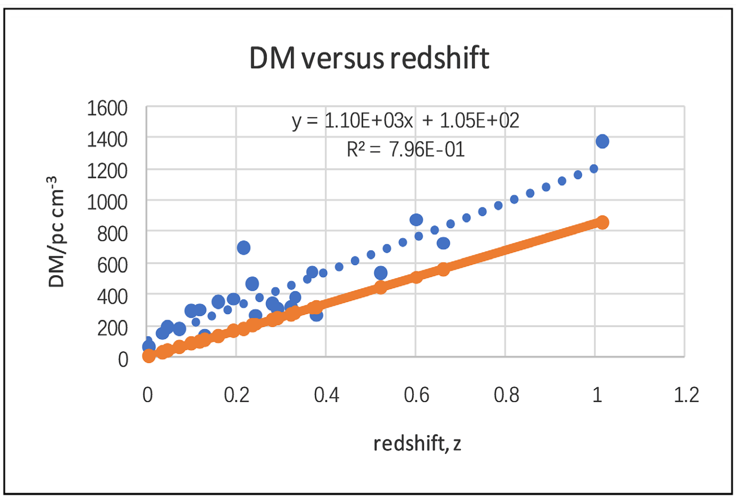

Figure 3. *DM-z* plot in traditional units. The red line shows the expected result given $DM_{IGM} \cong 850z$ for the Macquart relationship and an expanding universe.

and is shown in **Figure 3**.

The gradient of the trendline (blue dotted) is 1.10×10^3 pc·cm^{-3} and a discrepancy of 29% above predicted. Here, no attempt has been made to account for the host galaxy contribution to the observed DM and it is said that this causes points lie above the line [23].

The trend line has an intercept of 150 pc·cm^{-3} which cannot be assumed to be the, "mean contribution from the host galaxy" as in the expanding Universe Theory the DM from the host has to be weighted for redshift by $(1 + z)$ and this is different for each galaxy.

8. Determination of the Electron Number Density in the IGM

We can use the gradient of the graph of DM versus $\ln(1 + z)$ along with a value for the Hubble constant to determine the electron number density n_e, in the IGM.

From NTL the Hubble constant is given by Equation (2): $H = 2n_e hr_e/m_e$.

And the gradient of our graph, M is given by Equation (12): $M = m_e c/2hr_e$.

Combing these two relations gives: $n_e = HM/c$.

8.1. The Hubble Diagram

To derive the true value, we will dip into the NED-D online compilation of redshift independent extragalactic distances [44] along with the corresponding redshifts of over 15,000 cosmological objects to construct a model free Hubble Diagram of redshift versus distance for nearby galaxies. In NTL the redshift varies exponentially with distance and so we need relatively local cosmological objects (where $x \approx e^x - 1$) and so we are using 2000 of the most local objects from the list (less 32 outliers which have been removed manually, by eye.

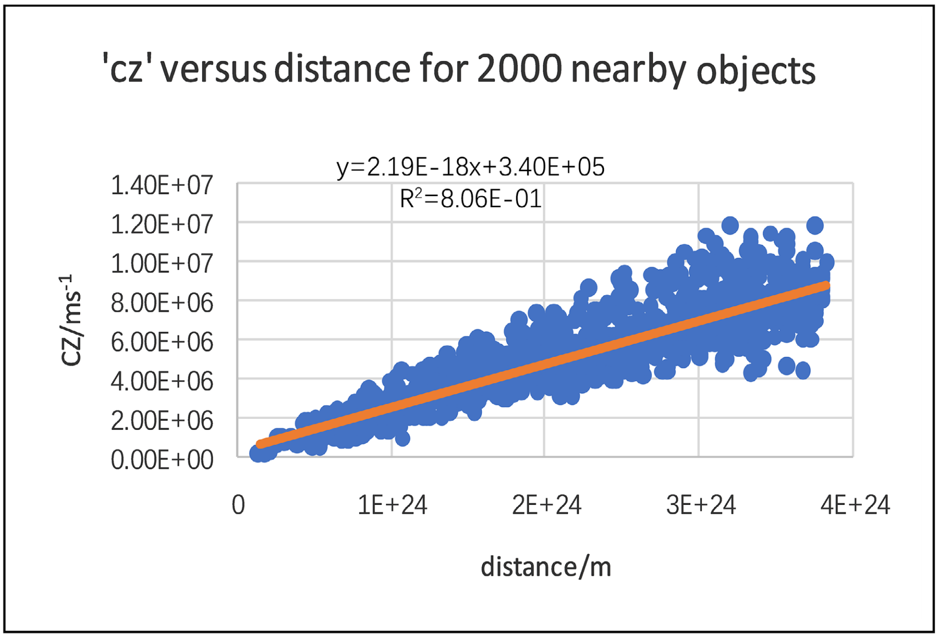

Figure 4. Graph of cz versus distance for 2000 nearby cosmological objects.

In **Figure 4**, We see that the gradient is $2.19 \times 10^{-18}\ \mathrm{s}^{-1}$ or $H = 67\ \mathrm{km \cdot s^{-1} \cdot Mpc^{-1}}$. Thus, this is our "true" value since it is independent of any model and it is this value that we must use to check our predicted Hubble constant from NTL. There is good correlation to a straight line fit with $R^2 = 0.81$. There is a slight positive intercept most likely due to the peculiar motion of close galaxies not in the Hubble flow.

8.2. Electron Number Density IGM

From **Figure 1**, the gradient from the twenty-three well localized FRB's, we see that the gradient, $M = 6.65 \times 10^{25}\ \mathrm{m}^{-2}$ giving a value of $n_e = 0.48\ \mathrm{m}^{-3}$ whilst from **Figure 2** the gradient, $M = 8.09 \times 10^{25}\ \mathrm{m}^{-2}$ giving a value of $n_e = 0.48\ \mathrm{m}^{-3}$ giving an average of 0.53 m^{-3}. This same value for $n_e = 0.5\ \mathrm{m}^{-3}$ has long since been predicted by NTL in a book published in 2004 [21] and published papers since 2006 [3].

9. Review of the Evidence for New Tired Light and a Static Universe

The idea of an expanding universe has been with us for almost one hundred years but during this time advances have been made both in theories and telescope technology and it is clear that the idea of expansion is not as clear cut as once thought. In particular, recent images from the James Webb Space Telescope show well-formed galaxies where well-formed galaxies should not be. That is, we see spiral galaxies at distances where the Big Bang theory tells us is the very beginning of the universe and have caused some astrophysicists to "panic", [45] or even suggest: "*Portrait of young galaxy throws theory of galaxy formation on its head*" [46]. More recently The JWST has discovered a galaxy larger than the Milky Way dating to 13 billion years ago (800 billion year after the Big Bang) [47]. One must ask, "*why is it that the theory of galaxy formation must be thrown out and not the Big Bang itself*?"

The "tension" in the Hubble constant, *H*—where different methods to measure *H* produce different values and these values fail to agree to the extent that if it were chance, it would be a 1 in 3 million [48] event. Some have said that "new" Physics or even "new" particles are needed to answer the "tension" [49].

The Tolman surface Brightness test [50] once a stalwart of "proof" of an expanding universe has now been extended with data from the Hubble Space Telescope and supports a static universe [51] and not an expanding one. Hence the need for NTL to explain the observed redshifts.

Supernovae Ia are said to show "*time dilation*," in support of expansion—though what is measured is that the light curves appear to be broader the farther away the supernova. It has been suggested that perhaps this is a result of the way the data is processed [52]. When supernova Ia are used to plot a Hubble diagram for large redshift, we find problems in that the results did not agree with the theory at that time and so "new" physics had to be invented to explain a proposed "*acceleration*" such as "dark energy" [53]—something to this day has neither been found or explained. Can we be sure of the data from these supernova Ia? In the same way, supernova Ia showing "*time dilation*" and "*relativistic recession speeds*" can be found at redshifts less than one ($z < 1$) and yet other data [54] show that the intervening Hydrogen clouds in the Lyman Alpha forest are evenly distributed in this same redshift range—indicating a static universe? Whilst it is said that Supernova Ia at large redshifts exhibit "*time dilation*" Qasar light curves do not [55]. How can this be?

We are told that a static universe is "*not possible*" as this would violate the General Theory of relativity but a recently published paper proposes a solution to GR that allows a static universe [56]. That is, NTL is consistent with the General Theory of Relativity.

The "*solar limb problem*", whereby anomalous redshifts increase in magnitude as one looks further and further away from the centre and towards the Solar limb has also been satisfactorily explained in terms of a photon—electron interaction [57]. Several attempts have been made to explain away these intrinsic redshifts in terms of convection currents in the solar corona [58] so as not to contradict an expanding universe but failed to resolve the issue convincingly. On the other hand, NTL has been used to, not only fully explain the shape of the anomalous redshift—radius curve, but has predicted the actual quantitative values which are in agreement with the observed shifts at the limb.

In a similar way, there is the Redshift Anomaly of the 2292 MHz Radio Signal Emitted by the Pioneer-6 Space Probe. As the probe passed behind the Sun the radio signals emitted by it suffered an anomalous redshift which went back to "*normal*" once it had emerged from behind the solar corona. This too has been explained both qualitatively and quantitively by Multiple Interactions with Photo-Ionized Electrons in the Solar Corona ie NTL [59].

More recently, data from the JWST has been used to resolve the issue that galaxies seen in the early Universe are similar to those in the late universe but have not had enough time for this evolution to take place. An "*angular diameter—redshift*" cosmological test was found with the conclusion, "*a static model can provide a natural and straightforward way of solving the puzzle of the well-evolved galaxies*" [60].

10. DM, NTL and the Milky Way Galaxy Halo

The question of, "*how is it that the Milky Way halo and ISM give a DM* (*which is subtracted from the overall data in this paper*) *and yet there is no redshift by NTL in this same plasma region*?" Well, the answer is twofold.

Firstly, in NTL, the redshifts are caused by electrons in the plasma recoiling on absorption and re-emission. This can only happen in a sparsely populated plasma. The denser the plasma, the stronger the repulsive forces between adjacent electrons and the less the recoil. Photons can still be "*slowed down*" to give a dispersion measure but recoil will be reduced.

Secondly, in order to create an "*electron glass*" or Wigner-Seitz crystal, we need very low temperatures, or very high electron densities or no protons. In the IGM, the protons are fixed on the dust particles, whilst the electrons fill the voids in-between arranging themselves in a BCC crystal lattice. Here dispersion can occur at the same time as a redshift by NTL. In the MW halo, the plasma is thought to be a neutral—with electrons and protons in equal numbers [61]. The conditions are not right for the free electrons to crystalise into an electron "*glass*" and consequently, they move randomly. Any photon-electron interaction in this region is Compton scatter which has a very small collision cross-section and, in any case, deviates the photons off course. Consequently, there is no redshift in the MW, ISM or halo but there is a DM.

A previous paper looked at the structure of the Milky way halo in a similar way to dust in the IGM and the photoelectric effect. Ultraviolet and X-ray photons leaving the interior of the galaxy would ionize Hydrogen atoms in the clouds surrounding the galaxy. The released electrons would go off into the IGM and arrange themselves on a Wigner-Seitz crystal lattice and contribute to the overall electron density in the IGM. The protons would be left behind to form the galaxy halo and possibly be the explanation of "*Dark matter*" [62]. Should this be the case, we would still have dispersion but little recoil and hence little redshift due to the mass of the protons being much higher than that of the electron.

An interesting aspect to the discovery of dispersion measure is that for years, tired light theories were rejected on the basis that they would scatter the image since it was said that there was no way a photon could interact with a "*free*" electron and yet continue in a straight line. And yet, here we have DM, said to be caused by a photon of radio frequency interacting with a "*free*" electron in the IGM—and these workers are looking along the direct line of sight for a galaxy that could be the possible host for the FRB—i.e. they assume the photons are not scattered in any way by what they consider to be "*free*" electrons. Furthermore, we omitted FRB 181112 from the analysis as the signal had passed through the halo of a foreground galaxy on its way to us and undergone dispersion. However, the signal continued in a straight line without scatter and emerged in pristine condition [63]. Apart from an addition to the DM there was no other effect that the plasma in the halo had on the signal. Anyone still under the opinion that tired light theories should be rejected as they "*scatter the image*" must also explain why dispersion measure (an interaction with the "*free*" electrons in the IGM) produces no scatter.

11. Discussion and Conclusions

Fast Radio Bursts are a recent tool that can be used to not only investigate the material in the IGM but also to test cosmological theories. Both the expanding universe theory and New Tired Light theory make predictions of a relationship between the Dispersion Measure of the fast radio burst and the redshift of the host galaxy and, as more and more hosts of FRB's are found, these predictions can be tested to a greater and greater extent. The "Macquart" relation involving an expanding universe is a very complicated mathematical relationship since expansion and *DM* are not directly related and involves "exotic" terms involving as yet undiscovered dark matter and energy. In NTL there is a direct relationship between redshift and *DM* since they both involve an interaction between photons and the electrons in the IGM. New Tired Light predicts a relationship between DM and redshift of $DM_{IGM} = \left(m_e c/2hr_e\right)\ln\left(1+z\right)$ which reduces to $DM_{IGM} = 7.318\times10^{25}\ln\left(1+z\right)$ in SI units when values for the universal constants are substituted. A graph of DM versus ln(1 + *z*) will be a straight line of gradient 7.318×10^{25} m^{-2} ($m_e c/2hr_e$) with an intercept equivalent to the host galaxy contribution to the DM. Using data from the 23 well localized FRB's gives a gradient of 6.65×10^{25} m^{-2} 10% below that predicted. Including the recently discovered FRB 20220610A, which has a redshift greater than "1", gives a gradient of 8.09×10^{25} m^{-2}—11% above that predicted and so we see that results are oscillating approximately 10% above/below that predicted as more results come in.

By itself, this is a good result for NTL in that the actual gradient is within 10% of that predicted but it cannot be stressed enough that this gradient is not just any number but a fixed combination of universal constants. There are no adjustable parameters or assumptions The predicted gradient is $m_e c/2hr_e$ and these are not just any random constants. NTL involves a photon—electron interaction and *h* and *c* are constants very much related to the photon ($E = hf$ and $c = f\lambda$) whilst m_e and r_e are constant parameters associated with the electron. Some may say that it is just a coincidence that the observed gradient is very close to $m_e c/2hr_e$—but if that is the case then it is a truly remarkable one at that.

NTL is a theory derived mathematically in its original form in 1996 and developed over the years—and yet 28 years on it is still the same basic theory. It has made predictions which later proved to be correct, for instance $n_e = 0.5\,\mathrm{m}^{-3}$ leading up to the *DM-z* relationship were, in 2017, on the discovery of the first localized FRB the gradient of the graph was predicted to be $m_e c/2hr_e$ and now, some seven year later, and with 23 localised FRB's, the gradient is within 10% of that predicted. This worker will continue to update the graph of *DM* versus ln(1 + *z*) as more and more data from localized FRB's comes in.

That the gradient is within 10% of a predicted combination of universal constants $\left(m_e c/2hr_e\right)$ relating to the photon and the electron comes only as a surprise to mainstream cosmologists since they prefer to work in the archaic units of the parsec instead of the SI system. This separates cosmology from the rest of science and makes seeing links hard to spot.

One must ask, "*In using these archaic units based on the mean radius of the orbit of the Earth about the Sun to distances in the whole of the Universe, are these cosmologists guilty of making the greatest school boy/girl howler of all time*?"

Conflicts of Interest

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

References

[1] Lorimer, D.R., Bailes, M., McLaughlin, M.A., Narkevic, D.J. and Crawford, F. (2007) A Bright Millisecond Radio Burst of Extragalactic Origin. *Science*, **318**, 777-780. https://doi.org/10.1126/science.1147532

[2] Pulsar Dispersion Measure. https://astronomy.swin.edu.au/cosmos/p/pulsar+dispersion+measure

[3] Lyndon Ashmore, B.A. (2006) Recoil between Photons and Electrons Leading to the Hubble Constant and CMB. *Galilean Electrodynamics*, **17**, 53-57. https://www.i-b-r.org/Incons.GravFinalGED-I.pdf

[4] Ashmore, L.E. (2019) Calculating the Redshifts of Distant Galaxies from First Principles by the New Tired Light Theory (NTL). *Journal of Physics*: *Conference Series*, **1251**, Article 012007. https://doi.org/10.1088/1742-6596/1251/1/012007

[5] Ashmore, L.E. (2022) Data from 14,577 Cosmological Objects and 14 FRBs Confirm the Predictions of New Tired Light (NTL) and Lead to a New Model of the IGM. *Journal of Physics*: *Conference Series*, **2197**, Article 012003. https://doi.org/10.1088/1742-6596/2197/1/012003

[6] Lorimer, D. (2016) Home of a Fast Radio Burst. *Nature*, **530**, 427-428. https://doi.org/10.1038/530427a

[7] Williams, P.K.G. and Berger E. (2016) Cosmological Origin for FRB 150418? Not So Fast. arXiv: 1602.08434. https://doi.org/10.48550/arXiv.1602.08434

[8] Zhou, B., Li, X., Wang, T., Fan, Y. and Wei, D. (2014) Fast Radio Bursts as a Cosmic Probe? *Physical Review D*, **89**, Article 107303. https://doi.org/10.1103/physrevd.89.107303

[9] James, C.W., Prochaska, J.X., Macquart, J., North-Hickey, F.O., Bannister, K.W. and Dunning, A. (2021) The *z*-DM Distribution of Fast Radio Bursts. *Monthly Notices of the Royal Astronomical Society*, **509**, 4775-4802. https://doi.org/10.1093/mnras/stab3051

[10] Hubble's Constant in Terms of the Compton Effect. https://www.angelfire.com/az/BIGBANGisWRONG/Hubble_latest_web.htm

[11] Shu, F.H. (2012) Intergalactic Medium. https://www.britannica.com/science/intergalactic-medium

[12] Cappelluti, N., Ranalli, P., Roncarelli, M., Arevalo, P., Zamorani, G., Comastri, A., *et al*. (2012) The Nature of the Unresolved Extragalactic Cosmic Soft X-Ray Background. *Monthly Notices of the Royal Astronomical Society*, **427**, 651-663. https://doi.org/10.1111/j.1365-2966.2012.21867.x

[13] Inoue, A.K. and Kamaya, H. (2010) Intergalactic Dust and Its Photoelectric Heating. *Earth*, *Planets and Space*, **62**, 69-79. https://doi.org/10.5047/eps.2008.10.003

[14] Wigner, E. (1934) On the Interaction of Electrons in Metals. *Physical Review*, **46**, 1002-1011. https://doi.org/10.1103/physrev.46.1002

[15] Wigner, E. (1938) Effects of the Electron Interaction on the Energy Levels of Electrons in Metals. *Transactions of the Faraday Society*, **34**, 678-685. https://doi.org/10.1039/tf9383400678

[16] Thomas, H., Morfill, G.E., Demmel, V., Goree, J., Feuerbacher, B. and Möhlmann,

D. (1994) Plasma Crystal: Coulomb Crystallization in a Dusty Plasma. *Physical Review Letters*, **73**, 652-655. https://doi.org/10.1103/physrevlett.73.652

[17] Gillespie, R.J. and Matta, C.F. (2001) Teaching the Vsepr Model and Electron Densities. *Chemistry Education Research and Practice*, **2**, 73-90. https://doi.org/10.1039/b1rp90010b

[18] French, A.P. (1968) Special Relativity. W. W. Norton & Company, 128.

[19] Feynman, R.P. (1990) QED—The Strange Theory of Light and Matter, Penguin, 76.

[20] Ashmore, L. (2015) An Explanation of Redshift in a Static Universe. In: Amoroso, R.L., Kauffman, L.H. and Rowlands, P. *Unified Field Mechanics*, Word Scientific, 456-463. https://doi.org/10.1142/9789814719063_0046

[21] Ashmore, L.E. (2006) Big Bang Blasted. BookSurge Publishing.

[22] Dispersion (optics). https://en.wikipedia.org/wiki/Dispersion_(optics)

[23] Fortunato, J.A.S., Hipólito-Ricaldi, W.S. and dos Santos, M.V. (2023) Cosmography from Well-Localized Fast Radio Bursts. *Monthly Notices of the Royal Astronomical Society*, **526**, 1773-1782. https://doi.org/10.1093/mnras/stad2856

[24] Kirshner, R.P. (2002) The Extravagant Universe. Princeton University Press, 70.

[25] Spitler, L.G., Scholz, P., Hessels, J.W.T., Bogdanov, S., Brazier, A., Camilo, F., *et al.* (2016) A Repeating Fast Radio Burst. *Nature*, **531**, 202-205. https://doi.org/10.1038/nature17168

[26] Bhandari, S., Heintz, K.E., Aggarwal, K., Marnoch, L., Day, C.K., Sydnor, J., *et al.* (2022) Characterizing the Fast Radio Burst Host Galaxy Population and Its Connection to Transients in the Local and Extragalactic Universe. *The Astronomical Journal*, **163**, Article 69. https://doi.org/10.3847/1538-3881/ac3aec

[27] Marcote, B., Nimmo, K., Hessels, J.W.T., Tendulkar, S.P., Bassa, C.G., Paragi, Z., *et al.* (2020) A Repeating Fast Radio Burst Source Localized to a Nearby Spiral Galaxy. *Nature*, **577**, 190-194. https://doi.org/10.1038/s41586-019-1866-z

[28] Bannister, K.W., Deller, A.T., Phillips, C., *et al.* (2019) A Single Fast Radio Burst Localized to a Massive Galaxy at Cosmological Distance. *Science*, **365**, 565-570. https://doi.org/10.1126/science.aaw5903

[29] Bhardwaj, M., Kirichenko, A.Y., Michilli, D., Mayya, Y.D., Kaspi, V.M., Gaensler, B.M., *et al.* (2021) A Local Universe Host for the Repeating Fast Radio Burst FRB 20181030a. *The Astrophysical Journal Letters*, **919**, L24. https://doi.org/10.3847/2041-8213/ac223b

[30] Bhandari, S., Sadler, E.M., Prochaska, J.X., Simha, S., Ryder, S.D., Marnoch, L., *et al.* (2020) The Host Galaxies and Progenitors of Fast Radio Bursts Localized with the Australian Square Kilometre Array Pathfinder. *The Astrophysical Journal Letters*, **895**, L37. https://doi.org/10.3847/2041-8213/ab672e

[31] Ravi, V., Catha, M., D'Addario, L., Djorgovski, S.G., Hallinan, G., Hobbs, R., *et al.* (2019) A Fast Radio Burst Localized to a Massive Galaxy. *Nature*, **572**, 352-354. https://doi.org/10.1038/s41586-019-1389-7

[32] Chittidi, J.S., Simha, S., Mannings, A., Prochaska, J.X., Ryder, S.D., Rafelski, M., *et al.* (2021) Dissecting the Local Environment of FRB 190608 in the Spiral Arm of Its Host Galaxy. *The Astrophysical Journal*, **922**, 173. https://doi.org/10.3847/1538-4357/ac2818

[33] Day, C.K., Deller, A.T., Shannon, R.M., Qiu, H., Bannister, K.W., Bhandari, S., *et al.* (2020) High Time Resolution and Polarization Properties of ASKAP-Localized Fast Radio Bursts. *Monthly Notices of the Royal Astronomical Society*, **497**, 3335-3350. https://doi.org/10.1093/mnras/staa2138

[34] Law, C.J., Butler, B.J., Prochaska, J.X., Zackay, B., Burke-Spolaor, S., Mannings, A., *et al.* (2020) A Distant Fast Radio Burst Associated with Its Host Galaxy by the Very Large Array. *The Astrophysical Journal*, **899**, Article 161. https://doi.org/10.3847/1538-4357/aba4ac

[35] Heintz, K.E., Prochaska, J.X., Simha, S., Platts, E., Fong, W., Tejos, N., *et al.* (2020) Host Galaxy Properties and Offset Distributions of Fast Radio Bursts: Implications for Their Progenitors. *The Astrophysical Journal*, **903**, Article 152. https://doi.org/10.3847/1538-4357/abb6fb

[36] Bhandari, S., Heintz, K.E., Aggarwal, K., Marnoch, L., Day, C.K., Sydnor, J., *et al.* (2022) Characterizing the Fast Radio Burst Host Galaxy Population and Its Connection to Transients in the Local and Extragalactic Universe. *The Astronomical Journal*, **163**, Article 69. https://doi.org/10.3847/1538-3881/ac3aec

[37] Fong, W., Dong, Y., Leja, J., Bhandari, S., Day, C.K., Deller, A.T., *et al.* (2021) Chronicling the Host Galaxy Properties of the Remarkable Repeating FRB 20201124a. *The Astrophysical Journal Letters*, **919**, L23. https://doi.org/10.3847/2041-8213/ac242b

[38] James, C.W., Ghosh, E.M., Prochaska, J.X., Bannister, K.W., Bhandari, S., Day, C.K., *et al.* (2022) A Measurement of Hubble's Constant Using Fast Radio Bursts. *Monthly Notices of the Royal Astronomical Society*, **516**, 4862-4881. https://doi.org/10.1093/mnras/stac2524

[39] Yang, K.B., Wu, Q. and Wang, F.Y. (2022) Finding the Missing Baryons in the Intergalactic Medium with Localized Fast Radio Bursts. *The Astrophysical Journal Letters*, **940**, L29. https://doi.org/10.3847/2041-8213/aca145

[40] Ryder, S.D., Bannister, K.W., Bhandari, S., Deller, A.T., Ekers, R.D., Glowacki, M., *et al.* (2023) A Luminous Fast Radio Burst That Probes the Universe at Redshift 1. *Science*, **382**, 294-299. https://doi.org/10.1126/science.adf2678

[41] Deng, W. and Zhang, B. (2014) Cosmological Implications of Fast Radio Burst/ Gamma-Ray Burst Associations. *The Astrophysical Journal*, **783**, L35. https://doi.org/10.1088/2041-8205/783/2/l35

[42] Zhang, B. (2018) Fast Radio Burst Energetics and Detectability from High Redshifts. *The Astrophysical Journal Letters*, **867**, L21. https://doi.org/10.3847/2041-8213/aae8e3

[43] Hessels, P.E. and Lorimer, D.R. (2020) Fast Radio Bursts at the Dawn of the 2020s. *Astronomy and Astrophysics Review*, **30**, Article No. 2. https://dare.uva.nl/search?identifier=5adc867b-d6e4-4b0c-9328-8f763da8bc12

[44] NED-D: A Master List of Redshift-Independent Extragalactic Distances. https://ned.ipac.caltech.edu/Library/Distances/

[45] Ferreira, L., *et al.* (2022) Panic! At the Disks: First Rest-Frame Optical Observations of Galaxy Structure at z>3 with JWST in the SMACS 0723 Field. arXiv: 2207.09428. https://arxiv.org/abs/2207.09428

[46] Portrait of Young Galaxy Throws Theory of Galaxy Formation on Its Head. https://www.cardiff.ac.uk/news/view/2497807-portrait-of-young-galaxy-throws-theory-of-galaxy-formation-on-its-head

[47] Turner, B. (2024) James Webb Telescope Finds Ancient Galaxy Larger than Our Milky Way, and It's Threatening to Upend Cosmology. https://www.livescience.com/space/cosmology/james-webb-telescope-finds-ancient-galaxy-larger-than-our-milky-way-and-its-threatening-to-upend-cosmology

[48] Dainotti, M.G., De Simone, B., Schiavone, T., Montani, G., Rinaldi, E. and Lambiase, G. (2021) On the Hubble Constant Tension in the SNe Ia Pantheon Sample. *The Astrophysical Journal*, **912**, Article 150.

https://doi.org/10.3847/1538-4357/abeb73

[49] Mörtsell, E. and Dhawan, S. (2018) Does the Hubble Constant Tension Call for New Physics? *Journal of Cosmology and Astroparticle Physics*, **2018**, Article 25. https://doi.org/10.1088/1475-7516/2018/09/025

[50] Lubin, L.M. and Sandage, A. (2001) The Tolman Surface Brightness Test for the Reality of the Expansion. IV. A Measurement of the Tolman Signal and the Luminosity Evolution of Early-Type Galaxies. *The Astronomical Journal*, **122**, 1084-1103. https://doi.org/10.1086/322134

[51] Lerner, E.J. (2018) Observations Contradict Galaxy Size and Surface Brightness Predictions That Are Based on the Expanding Universe Hypothesis. *Monthly Notices of the Royal Astronomical Society*, **477**, 3185-3196. https://doi.org/10.1093/mnras/sty728

[52] Crawford, D.F. (2017) A Problem with the Analysis of Type Ia Supernovae. De Gruyter. https://10.1515_astro-2017-0013.pdf

[53] Riess, A.G., Strolger, L., Tonry, J., Casertano, S., Ferguson, H.C., Mobasher, B., *et al.* (2004) Type Ia Supernova Discoveries at $z>1$ from the *Hubble Space Telescope*: Evidence for Past Deceleration and Constraints on Dark Energy Evolution. *The Astrophysical Journal*, **607**, 665-687. https://doi.org/10.1086/383612

[54] Number-Density Evolution of Lyman-Alpha Line. https://www.eso.org/public/images/eso0013g/

[55] Hawkins, M.R.S. (2001) Time Dilation and Quasar Variability. *The Astrophysical Journal*, **553**, L97-L100. https://doi.org/10.1086/320683

[56] Trinchera, A. (2023) Cosmological Redshift and Hubble Tension Explained by Means of the FLRWT Time-Metric Framework and Transit Physics in the IGM. *Frontiers in Astronomy and Space Sciences*, **9**, Article 1014433. https://doi.org/10.3389/fspas.2022.1014433

[57] Trinchera, A. (2021) Redshift Anomaly on the Solar Disk as Multiple Interactions between Photons and Electrons. *Journal of High Energy Physics*, *Gravitation and Cosmology*, **7**, 1-51. https://doi.org/10.4236/jhepgc.2021.71001

[58] Dravins, D. (1982) Photospheric Spectrum Line Asymmetries and Wavelength Shifts. *Annual Review of Astronomy and Astrophysics*, **20**, 61-89. https://doi.org/10.1146/annurev.aa.20.090182.000425

[59] Trinchera, A. (2021) Redshift Anomaly of the 2292 MHz Radio Signal Emitted by the Pioneer-6 Space Probe as Multiple Interactions with Photo-Ionized Electrons in the Solar Corona. *Journal of High Energy Physics*, *Gravitation and Cosmology*, **7**, 1107-1156. https://doi.org/10.4236/jhepgc.2021.73066

[60] Lovyagin, N., Raikov, A., Yershov, V. and Lovyagin, Y. (2022) Cosmological Model Tests with JWST. *Galaxies*, **10**, Article 108. https://doi.org/10.3390/galaxies10060108

[61] Ben Bekhti, N., Winkel, B., Richter, P., Kerp, J., Klein, U. and Murphy, M.T. (2012) An Absorption-Selected Survey of Neutral Gas in the Milky Way Halo. *Astronomy & Astrophysics*, **542**, A110. https://doi.org/10.1051/0004-6361/201118673

[62] Ashmore, L. (2019) Galaxies "Boiling off" Electrons Due to the Photo-Electric Effect Leading to a New Model of the IGM and a Possible Mechanism for "Dark Matter". *Journal of High Energy Physics*, *Gravitation and Cosmology*, **5**, 181-192. https://doi.org/10.4236/jhepgc.2019.51010

[63] ESO 2019 Enigmatic Radio Burst Illuminates a Galaxy's Tranquil Halo. https://www.eso.org/public/news/eso1915/

[64] Berestetskii, V.B., Lifshitz, E.M. and Pitaevskii, L.P. (1982) Quantum Electrodynamics, Volume 4. 2nd Edition, Butterworth Heinemann, 161-221.

[65] Mitchner, M. and Kruger, C.H. (1973) Partially Ionized Gases. Wiley Hoboken, 138.

[66] Plasma Frequency. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/plasma-frequency

[67] Cairns, R.A., Ersfeld, B., Johnson, D., McDonald, D.C. and Ruhl, H. (1998) Nonlinear Harmonic Response in Laser-Plasma Interactions. *Physica Scripta*, **75**, Article 99. https://doi.org/10.1238/physica.topical.075a00099

[68] Handbook of Space, Astronomy and Astrophysics. 286. https://ads.harvard.edu/cgi-bin/bbrowse?book=hsaa&page=286

[69] French, A.P. (1968) Special Relativity. W. W. Norton & Company, 176-182.

[70] Henke, B.L., Gullikson, E.M. and Davis, J.C. (1993) X-Ray Interactions: Photoabsorption, Scattering, Transmission, and Reflection at E=50-30,000eV, Z=1-92. *Atomic Data and Nuclear Data Tables*, **54**, 181-342. https://doi.org/10.1006/adnd.1993.1013

[71] Gullikson, E.M. (2001) X-Ray Data Booklet Section 1.7 Atomic Scattering Factors. https://physics.uwo.ca/~lgonchar/courses/p9826/xdb.pdf#page=75

[72] Cosmic Microwave Background Spectrum from COBE. https://lambda.gsfc.nasa.gov/product/cobe/cobe_images/firas_spectrum.jpg

[73] Longair, M.S. (1992) High Energy Astrophysics. Cambridge University Press, 79.

Appendix A

A.1. The New Tired Light Theory

The derivations of the New Tired Light Theory have been published in several scientific journals since 2006 and referenced in the main body of this paper. For ease, the main derivations are reproduced here as an appendix.

In NTL, the redshift is not a cosmological effect but more of an optical effect. When photons of light travel through glass they are repeatedly retained and re-released by the electrons in the atoms in glass [18]. To quote Feynman, "the transmission and reflection of light is nothing more than an electron picking up a photon, scratching its head so to speak and then emitting a 'new' photon" [19]. In the glass there is no recoil and no redshift, since the electron is held in an atom which in turn is held in the whole pane of glass and so it would be the entire pane that would recoil. With the electrons in the IGM, arranged on their BCC crystal lattice they too can perform SHM and so can absorb and re-emit photons of light [64] [65] and again there is a delay whilst the energy of the photon is transferred to the electron which now oscillates. But here, the individual electrons do recoil and energy is transferred from the photon to the recoiling electron on both retention and on release. The energy of the "new" photon is less than the original one and so the frequency is less, the wavelength is longer and thus it is redshifted.

The photon frequency is much greater than the natural frequency of the electron in its Wigner-Seitz crystal (which is equal to the plasma frequency, 30 Hz) [66]-[68] and so resonance absorption will not take place—the photon will always be re-released. We will see later that the energy transferred to the recoiling electron is released as subsidiary photons which form the CMBR.

The energy transferred to an electron by recoil is known [69] and equal to $Q^2/2m_ec^2$ where Q is the photon energy m_e the electron rest mass and c the speed of light. Since energy is lost on both retention and release, we must apply this twice so:

$$\text{Total energy “lost” per event } = \frac{Q^2}{m_ec^2} = \frac{h^2c^2}{\lambda^2c^2m_e^2} = \frac{h^2}{\lambda^2m_e^2}$$

or:

$$\frac{hc}{\lambda} - \frac{hc}{\lambda'} = \frac{h^2}{\lambda^2m_e} \tag{23}$$

where λ is the wavelength of the initial photon, λ' the wavelength of the released photon with h the Planck constant.

With $\delta\lambda = (\lambda' - \lambda)$ this reduces to:

$$\delta\lambda(\lambda m_ec - h) = h\lambda \tag{24}$$

The single term "h" can be ignored as $h \ll \lambda m_ec$ for wavelengths longer than $\approx 10^{-11}$ m and for those shorter this classical approach breaks down as recoil velocities approach the speed of light.

$$\delta\lambda = \frac{h}{m_e c} = 2.43 \times 10^{-12} \text{ m} \tag{25}$$

Whilst the photons traverse the IGM, they will "bump" into electrons on the way and each time the wavelength lengthens by an extra $h/m_e c$. If a photon travels twice as far through the IGM, it will bump into twice as many electrons, have its wavelength lengthen by twice as much such that the redshift doubles. This is what the Hubble Law is in reality. Remember that this derivation has been treated classically and is valid for all wavelengths longer than $\lambda \approx 10^{-11}$ m. For shorter wavelengths a relativistic approach is needed as the recoil velocity approaches the speed of light.

For cosmological objects far away, we must take into account that increasing the wavelength, increases the collision cross-section ,σ and this is known from low energy X-Rays interacting with matter [70] [71].

$$\sigma = 2 r_e \lambda f_2 \tag{26}$$

The term f_2 is the atomic photo-absorption cross section and refers to a photon being absorbed and not re-emitted—basically f_2 varies between 0 and the atomic number of the atom, Z—i.e. it varies between 0 and 1 for Hydrogen with the single electron. If the frequency is at one corresponding to an energy level, $f_2 = 1$ and the photon is absorbed and retained. If the frequency is far removed from one corresponding to an energy level, $f_2 = 0$. The photon is absorbed and a "new" photon released.

Collision cross-sections are probabilities and this one is the product of two. The first term, $2 r_e \lambda$ gives the probability of the photon being absorbed by the electron in the first place whilst f_2 is the probability of it being retained. There are only two possible outcomes thus if f_2 is the probability of retention, $(1 - f_2)$ is the probability of re-emission and thus transmission, i.e. a "new" photon released.

$$\sigma = 2 r_e \lambda (1 - f_2) \tag{27}$$

Wavelengths of radio and visible photons have a frequency much greater than the resonance frequency of the individual electrons on their crystal lattice and so we can apply this collision cross-section to them with f_2 as zero. The collision cross-section for retention followed by release of a photon is:

$$\sigma = 2 r_e \lambda \tag{28}$$

The mean free path is given by $(n_e \sigma)^{-1}$ or $(2 n_e r_e \lambda)^{-1}$ where n_e is the number density of electrons in the IGM and bearing in mind that the wavelength of the photon increases every time it "bumps" into an electron the mean free path will become shorter and shorter as it traverses the IGM.

The original wavelength is λ, increasing to $(\lambda + h/m_e c)$ after the first event, $(\lambda + 2h/m_e c)$ after the second, $(\lambda + 3h/m_e c)$ after the third and so on.

The total distance travelled, d, is equal to the sum of the mean free paths:

$$d=\left[2n_e r_e \lambda\right]^{-1}+\left[2n_e r_e\left(\lambda+h/m_e c\right)\right]^{-1}+\left[2n_e r_e\left(\lambda+h/m_e c\right)\right]^{-1} \\ +\cdots+\left[2n_e r_e\left(\lambda+\left(N-1\right)h/m_e c\right)\right]^{-1} \tag{29}$$

Or, d is given by:

$$\sum_{x=0}^{N-1}\left\{\lambda+x\left(\frac{h}{m_e c}\right)\right\}^{-1}=2n_e r_e d \tag{30}$$

Since $N \gg h/m_e c$ this approximates to:

$$\int_0^{N-1}\left\{\lambda+x\left(\frac{h}{m_e c}\right)\right\}^{-1}\mathrm{d}x=2n_e r_e d \tag{31}$$

Or:

$$\int_0^{N-1}\left\{\lambda+x\left(\frac{h}{m_e c}\right)\right\}^{-1}\mathrm{d}x=2n_e r_e d \tag{32}$$

i.e.

$$N=\lambda\left(m_e c/h\right)\exp\left(2n_e h r_e d/m_e c\right)+1-\lambda\left(m_e c/h\right) \tag{33}$$

Total increase in wavelength, $\Delta\lambda=N\delta\lambda$ ie $Nh/m_e c$

$$\Delta\lambda=\lambda\exp\left(2n_e h r_e d/m_e c\right)+h/m_e c-\lambda \tag{34}$$

Redshift, $z=\Delta\lambda/\lambda$

$$z=\exp\left(2n_e h r_e d/m_e c\right)+h/\left(m_e c\lambda\right)-1 \tag{35}$$

The term $h/\left(m_e c/\lambda\right)$ is small compared to other terms ($=2.42\times10^{-12}\lambda$) (for all wavelengths longer than X ray) it can be neglected in this classical non-relativistic determination.

$$z=\exp\left(2n_e h r_e d/m_e c\right)-1 \tag{36}$$

In the Hubble Law $v=Hd$ with $v=cz$

$$H=\left(c/d\right)\left\{\exp\left(2n_e h r_e d/m_e c\right)-1\right\} \tag{37}$$

For nearby galaxies we use the approximation $\mathrm{e}^x\approx1+x$

$$H=2n_e h r_e/m_e \tag{38}$$

Or:

$$z=\exp\left(Hd/c\right)-1 \tag{39}$$

The exponential function is linear for small values and so this reduces to, $z=Hd/c$ (or in expansion models, $v=Hd$ where $v=cz$).

A.2. The CMBR

As stated earlier, the energy transferred to the recoiling electron is re-emitted as two secondary photons—one absorption and one on re-emission.

Consider a photon in the UV, $\lambda=5\times10^{-8}$ m.

The momentum, p of this photon is given by $p=h/\lambda=1.33\times10^{-26}$ N·s.

On absorption, this momentum is transferred to the recoiling electron and by conservation of momentum, the recoil velocity of the electron will be 14,500 m^{-1}.

The kinetic energy gained by the recoiling electron is 9.64×10^{-23} J.

When this energy is emitted as a secondary photon the frequency is 1.45×10^{11} Hz. corresponding to a wavelength of 2.1×10^{-3} m.

This is the peak of the CMBR curve [72].

Photons of other frequencies will produce secondary photons of other wavelengths and hence the CMBR curve is produced. Plasma emits black-body radiation [73].