

This paper is a preprint and was presented at the Vigier 11 conference in Liege Belgium in Aug 2018. It will be published in the conference proceedings shortly

Calculating the redshifts of distant galaxies from first principles by the new tired light theory (NTL)

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Abstract. Contrary to popular belief it now appears that the intergalactic medium is filled electrons oscillating about fixed positions in a BCC Wigner crystal lattice. In NTL the photons of light are absorbed and re-emitted by these electrons which recoil leading to a photon energy loss and an increase in wavelength ie redshift. Since the electrons are spatially coherent, the photons will continue in a straight line and images will not 'blur.' FRB 121102 is a repeating FRB of known DM along with the distance and redshift of the host galaxy and enables us to test the NTL theory. The DM and distance give a mean electron number density of the IGM as $n \approx 0.498 \text{ m}^{-3}$ and we use this along with the distance to predict a value for the redshift of the host galaxy from first principles of $z = 0.143$ and a Hubble constant of $H_0 = 64 \text{ km/s per Mpc}$ This compares well with the measured value of 0.19273 and the optically measured $H_0 = 72 \pm 8 \text{ km/s per Mpc}$ In NTL, the energy transferred to the recoiling electron is re-emitted as a secondary photons which form the CMBR and it is shown that a UV photon of wavelength $\lambda = 5 \times 10^{-8} \text{ m}$ gives out a secondary photon of wavelength $2.06 \times 10^{-3} \text{ m}$ which is not only in the microwave region but is the wavelength at which the CMBR peaks. A review of the evidence once said to support expansion is carried out and it is seen that this evidence now either supports a static universe or is not as robust as once thought. Indeed, many of the SNe Ia's used to show 'time dilation' have since failed 'usability' test and are no longer listed in the SNe Ia catalogue,

1. Introduction

Fast Radio Bursts (FRB's) are a recently discovered phenomenon whereby extremely powerful radio signals lasting only a few milliseconds are received from outer space. Whilst opinions vary as to the source of these FRB's and what causes the radiation to be emitted, there is a general consensus that they are extra-galactic. What is often neglected is that regardless of what causes these events they are a useful tool to probe the intergalactic medium (IGM) and in particular, if the redshift of the host galaxy is known they can be used to determine the mean electron number density of the Intergalactic medium. There had been previous claims that the redshift of the host galaxy of FRB 150418 had been located but this was later found not to be the case [1]. Of all the FRB's detected so far, FRB 121102 appears to be the most interesting as it is thus far the only known repeating FRB. Whilst at first sight this seems to rule out theories linking FRB's to some cataclysmic event it did allow scientists to train telescopes upon it, wait

for the bursts to repeat and thus determine a closed set of independent data for this source including the redshift, the distance to the host galaxy and the dispersion measure. For the first time, this gives us the opportunity to test Tired Light models that rely on a photon-electron interaction quantitatively. That is we can use the distance and Dispersion measure of FRB 121102 to determine a predicted redshift and compare this to that measured independently. We shall see that the New Tired Light theory performs very well.

2. The intergalactic medium, IGM

2.1 Electron clouds and Wigner crystals

Until recently it had been assumed that the IGM was populated with neutral Hydrogen on a basis of approximately one atom per cubic metre of space but there is little to no actual data in support of this. A recently published paper [2] casts doubt upon this idea on the basis that galaxies must be ‘boiling off’ electrons from their outer surface by the photo-electric effect. High energy photons in the X-ray region striking Hydrogen atoms at the ‘surface’ of a galaxy would liberate an electron and give it sufficient energy to overcome the gravitational field of that galaxy and escape into the IGM. Since galaxies are billions of years old, this process has been going on for some time and thus the IGM should be filled with electrons. The remaining protons would be thermal and thus would not be able to escape the gravitational field but would remain to form a ‘positive spherical cloud’ surrounding the galaxy or galaxy cluster (and may be a possible explanation of ‘dark matter’). However, here will only concern ourselves on the cloud of electrons filling the IGM. Under certain conditions, such as temperature and electron density, an electron cloud will crystallise into a body centred cubic (BCC) crystal lattice known as a Wigner-Seitz crystal or ‘electron glass.’ Here the electrical potential energy of the electrons dominates their kinetic energy and the electrons are held in place by their mutual repulsion and oscillate about their lattice positions with simple harmonic motion (SHM). It is shown that these conditions are satisfied in the IGM and thus the cloud of electrons will crystallise into a body centred cubic (BCC) crystal. Additionally, as the electrons are spatially coherent on their ‘pinned’ lattice positions, photons of light will travel through the electron crystal in straight lines. There will be no ‘blurring’ of the image.

2.2 Determining the mean electron number density of the Intervening Intergalactic Medium (IGM).

FRB 121102 is presently the only known repeating fast radio burst and it is claimed that the dispersion measure (DM) of the FRB along with the redshift and distance to the host galaxy are known. Applying the cold plasma relationship to the dispersion measure enables us to find the mean electron number density, n , along the path followed by the radio signal as it crosses the IGM between source and Earth.

$$DM_{IGM} = nd \quad (1)$$

Where DM_{IGM} is the dispersion measure for the cold plasma of the IGM, n is the mean electron number density and d is the distance travelled in the IGM. Data for FRB 121102 is given in the table below [3,4,5].

Table 1. Data for

DM (measured)	$558.1 \pm 3.3 \text{ pc cm}^{-3}$	distance travelled in
DM_{NE2001}	$\approx 188 \text{ pc cm}^{-3}$	FRB 121102 is
DM_{halo}	$\approx 30 \text{ pc cm}^{-3}$	below [3,4,5].
DM_{host}	?	FRB 121102
DM_{IGM}	$\approx (340 - DM_{host}) \text{ pc cm}^{-3}$	
D_A	$\approx 683 \text{ Mpc}$	
D_L	$\approx 972 \text{ Mpc}$	
host redshift, z	0.19273 ± 0.00008	

Where D_A and D_M are the angular-diameter distance and the luminosity distance respectively. DM_{NE2001} and DM_{halo} are the maximum contributions to the measured DM by our own galaxy the Milky Way and its halo. DM_{host} is an unknown quantity and so we will set it to zero in our calculations and take $DM_{IGM} \approx 340 \text{ pc cm}^{-3}$ bearing in mind that this is now an order of magnitude value which we will be discussed later.

Using the angular-diameter distance $D_A \approx 683 \text{ Mpc}$ along with $DM_{IGM} \approx 340 \text{ pc cm}^{-3}$ gives a value for the mean electron number density of the IGM as:

$$n \approx 0.498 \text{ m}^{-3} \quad (2)$$

Whilst using the luminosity distance gives:

$$n \approx 0.350 \text{ m}^{-3} \quad (3)$$

3. *The transmission of light through the crystal.*

3.1 *The photon-electron recoil interaction.*

Due to photo-electric emission of electrons from the surface of galaxies, the IGM consists of pure electron clouds with neutral Hydrogen atoms in the background. The condition for a Wigner-Seitz crystal to form are that the electric potential of an electron is greater than it's kinetic energy. In a pure electron cloud in the IGM this condition is easily satisfied - even at high temperatures (50,000K and above [2]), and so the electrons are arranged upon a BCC lattice performing simple harmonic motion (SHM) about their 'pinned' position. Any electron that can perform SHM can absorb and emit photons of electro-magnetic radiation. This is the way light travels through a transparent material. The photon comes along and is absorbed by an electron in an atom. The electron-nucleus system oscillates and the photon energy has been transferred to vibrational-electrical energy in the atom. After a short delay a new photon is emitted [6]. In a block of glass the electron is 'fixed' within the atom which is 'fixed' within the block of glass and so there is no recoil on absorption or emission [7]. There is no energy loss to the electron due to recoil and so the absorbed photon and the emitted 'new' photon have the same energy, frequency and wavelength and can be considered to be the 'same' photon.

However, in the sparsely populated cold plasma of the IGM this is not the case. When a photon interacts with an electron, the electron is set into SHM as the energy of the photon is transferred and stored as vibrational energy of the electron in the crystal lattice. Since the plasma crystal is not very dense the electrons are not 'fixed' in place as in glass but can and do recoil. Whilst most of the energy of the incoming photon has been stored in the vibrating system, some of it has been transferred to kinetic energy of the recoiling electron. On re-emission, the electron again recoils and again some of the photon's energy has been 'lost' to the recoiling electron. The energy of the re-emitted 'new' photon is less. The frequency is less and it's wavelength larger. It has been redshifted.

The photon will make many such interactions on its journey and thus the Hubble law becomes, 'photons of light from a galaxy twice as far away, travel twice as far through the intergalactic medium, interact with twice as many electrons, lose twice as much energy due to recoil, undergo twice the loss in frequency ($E = hf$) and experience twice the increase in wavelength ($c = f\lambda$).'

Now that we have a value for the mean electron number density for the IGM it becomes a simple matter to use standard Physics to predict the redshift of the host galaxy of FRB 121102 in terms of a photon-electron recoil interaction (New Tired Light) and compare the predicted value with the actual measured value. We will see that they are in very good agreement.

4. *This is not the Compton effect!*

Before we perform the calculations let us be in no doubt that this photon-electron recoil interaction (New Tired Light) has nothing to do with the Compton Effect. The Compton Effect is for an interaction between a photon and a totally free electron. In the Compton Effect there is no mechanism by which the electron can store the energy of the incoming photon as potential, vibrational or whatever. The 'new' photon must be emitted simultaneously with the absorption of the old one. There can be no recoil in the forward direction and thus no energy loss in this direction. The only way the Compton Effect can produce a 'loss' in energy to the photon is by 'scatter' whereby the photon goes off one way and the

electron in another in order to conserve momentum. This would lead to a blurring of the image which is not seen. Consequently Compton Effect cannot be responsible for the redshift in distant galaxies. In New Tired Light the electrons in the IGM, arranged in their BCC lattice formation can oscillate and thus there is a mechanism by which the electron can store the energy of the photon. There is a delay during which the electron recoils twice – once on absorption and again on re-emission. The recoil takes place along the line of sight and so there is no scattering of the light. Since the electrons are arranged in a spatially coherent manner, the light travels in a straight line. New Tired Light does not destroy or ‘blur’ the image and thus is in agreement with observation.

5. Predicting redshift from first principles.

5.1 Increase in wavelength at each interaction.

Since the increase in wavelength at each photon-electron recoil interaction is small we need to use exact numbers with a large number of significant figures. Consequently we will not use an actual emission/absorption line as they are not known to the precision required. Let us consider a photon having an initial wavelength of $\lambda = 5.000000000 \times 10^{-7} \text{ m}$. Since this is in the middle of the range of visible light, surely one such photon must exist.

We will firstly calculate the increase in wavelength at each individual interaction. Values used for the constants are those published by CODATA 2014 [8].

The momentum, p of the photon is given by:

$$p = \frac{h}{\lambda} \quad (4)$$

Where h is the Planck constant. Hence:

$$p = 1.325214008 \times 10^{-27} \text{ N s} \quad (5)$$

By conservation of momentum, all this momentum is transferred to the recoiling electron. Using $p = mv$ gives the recoil velocity.

$$v = 1,454.7790190975 \text{ m s}^{-1} \quad (6)$$

Note that for low energy photons below X-ray the recoil velocity is non-relativistic and so classical physics may be used.

The kinetic energy transferred to the recoiling electron is given by $KE = mv^2/2$ and this is the amount of energy ‘lost’ by the photon to the recoiling electron.

Energy transferred to recoiling electron E_{recoil} is:

$$E_{recoil} = 9.6394676732628 \times 10^{-25} \text{ J} \quad (7)$$

Whilst the energy ‘lost’ on re-emission to the recoiling electron will be slightly less than this amount as the emitted photon has slightly less energy, a lower frequency, a longer wavelength and thus less momentum it is a good approximation here to consider them the same. Hence we must double this figure to find the total energy transferred to the recoiling electron at each interaction.

$$\text{Total energy transferred}_{recoil} = 1.9278935346526 \times 10^{-24} \text{ J} \quad (8)$$

The energy, E_0 of the original photon is found from, $c = f\lambda$ and $E = hf$ to give:

$$E_0 = 3.97289164834351664 \times 10^{-19} \text{ J} \quad (9)$$

To find the energy of the re-emitted photon we must subtract the energy transferred due to recoil as in equation (8) from the energy of the incoming photon as in equation (9).

$$\text{Energy of reemitted photon} = 3.9728723694082 \times 10^{-19} \text{ J} \quad (10)$$

Using $E = hf$ and $c = f\lambda$ we can determine the final wavelength, λ_f of the re-emitted photon.

$$\lambda_f = 5.00002426 \times 10^{-7} \quad (11)$$

The increase in wavelength, $d\lambda$ at this one interaction is found by subtracting λ_i from λ_f to give:

$$d\lambda = 2.426 \times 10^{-12} \text{ m} \quad (12)$$

As the photon travels through the IGM it will make many such interactions as it encounters electron after electron in the cold plasma and each time the wavelength of the photon will increase by $2.426 \times 10^{-12} \text{ m}$. Despite the New Tired Light theory being completely different to the Compton effect it is interesting to note that this quantity has the same value as the ‘Compton Wavelength’ or ‘Compton constant.’ Note also that there is now no need to continue using nine significant figures.

5.2 Collision cross-section and mean free path.

The collision cross-section, σ represents the probability of the photon encountering an electron and being absorbed by it. The collision cross-section for a photon being absorbed by an electron is known from the interaction of low energy X-Rays with matter [9,10,11].

$$\sigma = 2r\lambda \quad (13)$$

Where r is the classical electron radius, $r = 2.8179 \times 10^{-15} m$.

For our photon of initial wavelength $5 \times 10^{-7} m$ the collision cross-section is:

$$\sigma = 2.8179 \times 10^{-21} m^2 \quad (14)$$

The mean-free path, l , is given by:

$$l = (n\sigma)^{-1} \quad (15)$$

$$\text{or } l = (2r\lambda n)^{-1}$$

Where, n is the mean electron number density found earlier.

For this ‘first principles’ calculation we will assume that σ is constant throughout the photon’s journey. However this is not the case as the wavelength and hence σ will increase every time the photon interacts with an electron. The photon will make more and more collisions as the mean distance between collisions becomes shorter and shorter. This will lead to a small underestimation of the redshift but as we will see, is sufficient for our purposes here. We saw earlier in equations (2) and equations (3) that the value of n depends upon the method used to determine the distance. It actually makes little difference to our calculation here which set of values we use. We will use the angular-diameter distance, $D_A \approx 683 \text{ Mpc}$ and the resulting mean electron number density, $n \approx 0.498 \text{ m}^{-3}$ as an example here.

Mean-free path is:

$$l = 7.126 \times 10^{20} m \quad (16)$$

That is, our photon will travel just over $7 \times 10^{20} m$ between each interaction or, to put it another way, the photon will interact with an electron once every 75,300 year.

5.3 Calculating the redshift of FRB 121102

Knowing the mean free path and the increase in wavelength at each interaction we are now in a position to calculate the redshift of the host of FRB 121102.

To find the total number of interactions, N encountered by our photon on its journey we simply divide the distance travelled by the mean-free path:

$$N = D_A/l$$

$$\text{or } N = 29,540 \quad (17)$$

Since $D_A \approx 683 \text{ Mpc} \approx 2.108 \times 10^{25} m$. That is, on its journey, our photon will make just over 29,000 interactions and each time the wavelength will increase by $d\lambda = 2.426 \times 10^{-12} m$.

The total increase in wavelength encountered by our photon during the entire journey is:

$$\Delta\lambda = N(d\lambda)$$

$$\text{or } \Delta\lambda = 7.167 \times 10^{-8} m \quad (18)$$

The redshift, z is defined as:

$$z = \frac{\Delta\lambda}{\lambda}$$

$$\text{giving } z = 0.143 \quad (19)$$

This compares favourably with the reported redshift of the host of 0.19273 ± 0.00008 – a difference of 26%. It should be remembered that whilst we did not include a DM for the host galaxy (a contribution that would reduce our predicted value of z , the contribution included for the Milky Way, $DM_{NE2001} \approx 188 \text{ pc cm}^{-3}$ is a maximum value and should it be less it would bring our predicted z closer to the reported value. If we take into account the increasing wavelength and hence collision cross-section encountered by the photon during its journey [1,12] the predicted redshift by New Tired Light is $z = 0.154$ – a difference of 20% from the recorded value.

5.4 The Hubble Constant, H_0

Having predicted the redshift of FRB 121102 using New Tired Light as $z = 0.1433$ and knowing the distance to the host galaxy $D_A \approx 683 \text{ Mpc} \approx 2.108 \times 10^{25} \text{ m}$, it becomes a simple matter to calculate a predicted value of the Hubble constant, H_0 .

$$v = H_0 d \quad (20)$$

Since $v = cz$

$$H_0 = \frac{cz}{d} \quad (21)$$

Giving a predicted value of:

$$H_0 = 2.05 \times 10^{-18} \text{ s}^{-1} \quad (22)$$

Which in cosmological units is:

$$H_0 = 64 \text{ km/s per Mpc} \quad (23)$$

This predicted value is within 11% of that measured optically by the Hubble space telescope ($72 \pm 8 \text{ km/s per Mpc}$ - and lies within the uncertainties of the method [13].

5.5 Predicting the CMB

But what of the energy transferred to the recoiling electron? In NTL, this is emitted as a secondary photon. There are two secondary photons emitted during each interaction as the electron recoils – one on absorption and another on re-emission. We saw in equation (7) that the recoil energy transferred to the electron on absorption is $E_{recoil} = 9.639 \times 10^{-25} \text{ J}$. By using $E = hf$ and $c = f\lambda$ we can calculate the wavelength of these photons, λ_{CMBR} and it is they that make up the Cosmic Microwave Background Radiation.

$$\lambda_{CMBR} = 0.21 \text{ m} \quad (24)$$

We see that this secondary photon is in the microwave region of the E-M spectrum. Whilst the increase in wavelength suffered by each photon is the same regardless of the energy of the incoming photon, the recoil energy transferred to the electron differs. Consequently each wavelength/energy of incident photon contributes secondary photons in different parts of the CMBR microwave spectrum. It is known that plasma emits black body radiation [14].

5.6 Repeating with a UV photon to show that redshift is independent of wavelength

From observation, the redshift, z is independent of the wavelength of the spectral line *ie* $z = \Delta\lambda/\lambda$ is a constant for all wavelengths. In NTL this is achieved in view of the collision cross-section. The collision cross-section ($\sigma = 2r\lambda$) is proportional to the wavelength of the photon. Consequently a photon with twice the wavelength has twice the collision cross-section, makes twice as many interactions in travelling the same distance, undergoes twice the shift in wavelength such that the ratio $\Delta\lambda/\lambda$ remain the same.

Let us briefly repeat the prediction using a photon in the UV range; $\lambda = 5 \times 10^{-8} \text{ m}$. The momentum is $p = 1.325214008 \times 10^{-26} \text{ N s}$ and once absorbed this momentum has been transferred to the electron giving a recoil velocity of $14,547.7902 \text{ ms}^{-1}$. The kinetic energy associated with this recoil is $9.6394676732628 \times 10^{-23} \text{ J}$. We double this to find the total energy 'loss' of the photon as it is absorbed and then re-emitted and subtract it from the initial energy of the photon ($E = hf = 3.97289164834351664 \times 10^{-18} \text{ J}$) to find the energy of the re-emitted photon $E = 3.9728723694082 \times 10^{-19} \text{ J}$. The wavelength associated with this photon is $\lambda = 5.0002426 \times 10^{-8} \text{ m}$. This gives an increase or shift in wavelength of $d\lambda = 2.426 \times 10^{-12} \text{ m}$. The same as before.

We now need to calculate the number of collisions suffered by this photon on its journey through the IGM. The collision cross-section is $\sigma = 2r\lambda = 2.818 \times 10^{-22} \text{ m}^2$. Using the same electron number density, $n \approx 0.498 \text{ m}^{-3}$ giving a mean free path of $7.126 \times 10^{21} \text{ m}$. Consequently the photon in the UV will only interact with an electron in the IGM once every 750,000 year. The total number of interactions N is found by dividing the distance ($D_A \approx 683 \text{ Mpc} \approx 2.108 \times 10^{25} \text{ m}$) by the mean free path to give $N = 2958$. On each interaction the wavelength increases by $d\lambda = 2.42642 \times 10^{-12} \text{ m}$ and so the total increase in wavelength is $\Delta\lambda = 7.1778 \times 10^{-9} \text{ m}$. Dividing this by the original wavelength ($5 \times 10^{-8} \text{ m}$) gives $z = 0.143$.

Thus NTL agrees with the result that redshift z is the same for all wavelengths.

We will now calculate the wavelength of secondary photons given off by the recoiling electron. Kinetic energy transferred to the electron on recoil is $9.639 \times 10^{-23} \text{ J}$ and if this is emitted as a secondary photon the wavelength will be $2.06 \times 10^{-3} \text{ m}$. This photon is not only in the microwave region but is exactly the wavelength at which the CMBR peaks [15]. Again, these secondary photons are given out by the plasma crystal and plasma is known to emit Black Body radiation.

6. Relationship between redshift, z and DM

In the New Tired Light theory, redshifts are produced by the photons of light interacting with the electrons in the intergalactic medium. Dispersion measure is known to be produced by an interaction between the photons and the same electrons. Consequently, if redshifts are produced by a photon-electron interaction then one would expect a relationship between the two in the sparsely populated plasma of the intergalactic medium that is independent of the mean electron number density. We would also not need to choose between D_A or D_L since our relationship would be independent of distance as well as n . It should be noted that as the plasma becomes denser it becomes ‘stiffer’ and so the electrons cannot recoil. There is no redshift in dense plasma but there will still be dispersion.

The cold plasma dispersion equation is:

$$DM_{IGM} = nd \quad (25)$$

In New Tired Light the full algebraic redshift – distance formula is:

$$z = \exp(Hd/c) - 1 \quad (26)$$

Where:

$$H = 2nhr/m \quad (27)$$

Rearranging both formulae to make ‘ d ’ the subject, equating and simplifying gives:

$$DM = \frac{mc}{2hr} \ln(1 + z) \quad (28)$$

Inserting values for m, c, h and r along with a unit conversion factor to enable us to use DM in $pc \text{ cm}^{-3}$ And the rest in SI gives:

$$DM = 2380 \ln(1 + z) \quad (29)$$

Note that a graph of DM against z will be a straight line passing through the origin of gradient 2380 pc cm^{-3} . FRB 121102 has a $DM_{IGM} \approx 340 \text{ pc cm}^{-3}$ and $z = 0.19273$ giving:

$$DM = 1930 \ln(1 + z) \quad (30)$$

The percentage difference in the constant term being just 19%. It is proposed that this difference is due to our taking the maximum value of DM_{NE2001} for the Milky Way as $\approx 188 \text{ pc cm}^{-3}$. Should it be less, our predicted value for the constant would have a lower percentage error.

There is an attempt to draw a graph of DM versus redshift in reference [1]. However we need more data to do this fully as presently we only have one accepted FRB with known redshift of host galaxy. It will be interesting to plot this graph as we collect more data.

7. Review of the Evidence For an Expanding Universe

With the realisation that the IGM must be filled with electrons with a few neutral Hydrogen atoms in the background and that these electrons crystallise onto a BCC lattice, the objection to Tired Light that images would be blurred has been removed. The previous sections calculated both the redshift of the host of FRB 121102 from first principles using a photon-electron recoil interaction and the mean electron number density found from the DM of the FRB itself. We also saw that the secondary radiation emitted by the recoiling electron is not only in the same region as the CMBR but that given off when a UV photon interacts with an electron is at the same wavelength as that at which the CMBR peaks. The predicted redshift was in good agreement with that recorded from observation. All this without involving ‘expansion of the universe.’ That is, these results show that we can explain redshift and the CMBR in a static universe without the need for expansion. The idea of a static universe was ruled out at the turn of the 21st Century as test after test was said to ‘rule out’ a static Universe in favour of one that expanded.

However, science, and cosmology in particular, continues to move forward and so perhaps it is time to revisit these tests and see how they have fared with time.

7.1 The Tolman Surface Brightness Test

The surface brightness of galaxies should decrease in proportion to $(1+z)^{-n}$ and ‘ n ’ has different values dependent upon the model. In a static universe $n = 1$ whilst in an expanding universe $n = 4$ [16]. A test carried out in 2001 [17] found values $n = 2.59 \pm 0.17$ in the ‘R band’ and $n = 3.37 \pm 0.13$ in the ‘I band.’ It was said that the results favoured an expanding universe and ruled out a static one. Whilst at first sight these results do not appear to be overly convincing (whilst a cynic may even say they just ‘split the difference’) we must also remember that the test does not compare like with like. Different galaxies at different distances are compared and even if the two galaxies are identical the further one is younger than the nearer one at the time the comparison takes place simply because it takes light longer to reach us the farther the galaxy. The differences could be due to evolution of the galaxies. More recently the test has been repeated over a much larger range [18]. The UV surface brightness of galaxies from the local universe to $z \sim 5$ was compared using the HUDF and GALEX datasets. They concluded “that available observations of galactic SB are consistent with a static Euclidean model of the universe.” That is, according to the Tolman test, the universe is static.

7.2 Hydrogen Cloud Separation

It has been proposed [19] that Hydrogen cloud separation could give a measure of the dynamics of the Universe. In the spectrum of distant quasars is the Lyman Alpha forest. Quasars are thought to be intensely bright objects and for some, their light has travelled far across the universe. Each time the light passes through a Hydrogen cloud certain frequencies of light are absorbed by the Hydrogen atoms. This line is then redshifted as the light continues to the next Hydrogen cloud where the same frequency of light is absorbed once again. In this way a whole series or ‘forest’ of lines is imprinted on the spectrum of Quasar light and acts as a ‘ticker tape’ displaying the dynamics of the universe over almost it’s entire history. Researchers have divided the redshift into ‘bins’ of size dz and counted the number of lines, dN in each bin. From this they calculate the number of lines per unit redshift, dN/dz . The inverse of this gives the mean distance in redshift between the Hydrogen clouds.

In an expanding universe one would expect the mean spacing to increase as the light has to travel farther and farther between Hydrogen clouds since the Universe has expanded during it’s journey. In an expanding universe we would expect dN/dz to decrease as the universe ages and as the redshift reduces. In a static universe, we would expect the mean cloud spacing to be constant and thus dN/dz to be constant with age and hence redshift.

Fig. 1. This image shows the number-density evolution of the Lyman alpha lines, observed with UVES in the quasars HE22-28 and QSO J2233-606.

Credit: ESO <https://www.eso.org/public/images/eso0013g/>

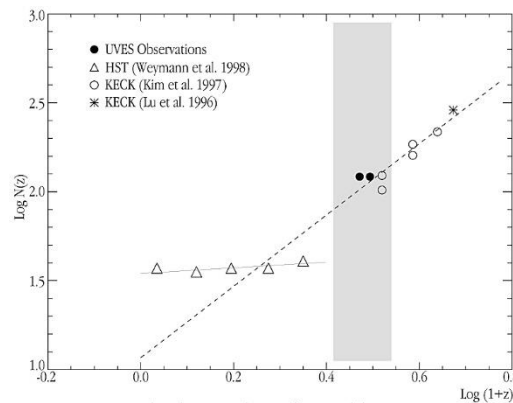


Fig 1. shows the line counts $\text{Log}N(z)$ with redshift as published by the ESO [20]. If we take the results at face value we see a universe expanding in the past from $z = 0.8$ to $z = 0.4$ but a static universe from $z = 0.4$ to the present. That is, taken at face value, the line density evolution is consistent with a universe that expanded in the past but due the density being equal to the critical density, the expansion stopped and the universe has been at rest for the past billion year or so.

Some workers report that the mean cloud separation is constant up to a redshift of 1.6 [21]. This includes most of the supernovae reported to show time dilation. How is it that we have supernovae reportedly showing relativistic time dilation due to expansion lying amongst H1 clouds which are evenly spaced? Note that FRB 121102 has a host galaxy with a redshift of $z = 0.19273$ and thus lying in the middle of the flat part of the curve in Fig 1 where the clouds are evenly spaced.

7.3 Supernovae Light Curve Broadening

This observation is often given as the main evidence against a static universe and hence Tired Light models. It is said to be due to ‘time dilation,’ but this must be treated with caution as it is not a result but an interpretation of the data in terms of an expanding universe. What was thought to be seen is ‘the further away the supernova, the longer it took to reach maximum brightness and then fade.’ However, a recently published study of the raw data of over seven hundred Supernovae without using SALT2 methods of analysis showed no ‘time dilation’ at all [22]. That is the reported time dilation is an effect produced by the methods of analysis rather than the supernovae data itself. The conclusions of this study are:

- Type Ia supernovae light curves calibrated with SALT2 or other rest frame methods cannot provide tests of cosmology
- Widths of SALT2 template light curves are consistent with a static universe.
- Type Ia supernovae do not show time dilation
- The peak magnitudes of type Ia supernovae are consistent with a static universe.

These results are certainly consistent with the light curves of quasars. These too, vary in brightness in a measured way but despite several attempts to measure ‘time dilation effects,’ [23,24,5] there is no evidence for it at all. Quasar light curves do not show any broadening and thus no ‘time dilation.’ Quasar light curves show a static universe and thus rule out expansion. Since ‘curve broadening’ or ‘time dilation’ is said to be due to expansion of the intervening space then we would expect both sets of results to agree – unless the broadening is intrinsic to the supernovae Ia or a result of the data processing that has been applied to their results.

Whilst we wait for the reaction to the Crawford paper, let us look at the previous interpretation of the light curves and consider how they could be ‘broadened’ in a static universe.

The result could be explained by a Malmquist bias [26]. As we look deeper and deeper into space we have to look for brighter and brighter supernovae since the dimmer ones will be too dim to be seen. It is known that not all supernovae Ia have the same intrinsic brightness and that the brighter the supernova the longer it takes to fade away. Hence the more distant a supernova, the brighter it is and the broader the light curve.

Can we still be sure that Supernovae Ia are indeed the standard candles we once thought? At first it was thought that supernovae Ia were caused by accretion from a nearby star and thus identical but a recent paper argues the view that they are due to the merger of binary white stars or other compact stars. If we are not clear on how they form how can we be sure that they are all the same? In 2017 [27] researchers reported that SN 2012ca, a type Ia supernova had X-Rays in its spectra consistent with it exploding into a dense surrounding medium. This is typical of a core-collapse Type IIn SNe, ‘Thus, while the spectra suggests a Type Ia SNe, the X-ray luminosity, high density, and circumstellar interaction are typical of a core-collapse Type IIn SNe, suggesting a CSM similar to that seen in SNe IIn.’ [28]. If SN 2012ca is a Type IIn SNe then why has it a light curve similar to that of a Ia? There are many questions still to be answered regarding SNe Ia’s before we use them as definitive proof of an expanding or static universe. One must ask, ‘have the papers purportedly showing ‘time dilation’ stood the test of time?’ The ‘UNION 2.1 SNIA Compilation’ [29] lists all supernovae currently classed as SN Ia’s. Out of the 833

SNe Ia's listed in the data sets only 580 passes 'usability' tests and are included in the compilation. Nearby supernovae were dropped as their redshifts were too small to be reliably in the Hubble flow. However, more distant SNe Ia's were omitted from the compilation since they failed to show that they were reliably SNe Ia's. In 2001 Goldberger et al published a paper comparing the light curve widths of thirty five distant SNe Ia's with those of local ones [30]. Of the thirty five distant SNIa's, eight do not appear to be in the UNION Compilation and must be removed from the data set. In 2008, Blondin et al published a paper comparing the light curve widths of thirteen high redshift SNIa's against a template formed from the light curves of twenty local ones [31]. This paper is the one mostly put forward in any discussion on Tired Light to discredit the theory. Of the twenty local SNe Ia's, sixteen do not appear to be included in the compilation and of the thirteen distant SNe Ia's only one (2001go) appears to be included in the compilation. Consequently if this data were to be revisited and only including those SNIa's listed in the compilation, it would consist of the light curve from a single distant SNe Ia compared to a template formed from four local ones! It must be said that using the remaining SNe Ia's listed in the compilation, there is still evidence in the three papers for broadening of the light curves as the redshift increases – however, the results are clearly not as robust as once thought.

7.4 Is the Universe Cooling Down after the 'Hot' Big Bang?

In the 'Big Bang Theory' the Universe is said to have started in a 'Hot Big Bang' and cools as it expands from that point on. But what evidence is there that this is actually happening? As discussed earlier, the Lyman Alpha forest in the spectra of distant quasars gives us the history of the dynamics of the Universe and the width of the lines provides evidence for the temperature of those clouds over a large range of redshifts.

The Doppler parameter, b , is a measure of the line width and is related to the temperature of the gas in the cloud by:

$$b^2 = b_{th}^2 + b_{nt}^2 \quad (31)$$

Where b_{th} and b_{nt} are the thermal and non-thermal broadening of the line. Consequently b gives an upper limit to the temperature of the cloud. Lehner et al [32] looked at the Doppler parameter in the lines of Quasars with redshifts from those of the local Universe up to $z = 3.6$ and concluded, '*This suggests that a larger fraction of the low- z universe is hotter than at $1.5 \leq z \leq 3.6$ and/or the low- z universe is more kinematically disturbed than the high- z universe.*' That is, the Universe is hotting up rather than cooling down!

These results once again go against an expanding Universe. It also raises problems for the CMBR. The CMBR measured on Earth is a combination of radiation from different parts of the Universe that all happen to arrive here at the same time and produce a 'perfect black body curve'. The CMBR will also be redshifted in an expanding Universe and if it were not for a temperature difference the black body curve from distant parts would be redshifted and have a longer wavelength than that from the local Universe. The peaks would not coincide and the resulting curve would be anything but black-body.

The CMBR curve being black-body relies on the Universe cooling down. The temperature is said to increase as $(1 + z)$ and so radiation from more distant parts will be at a higher temperature, the wavelengths will be shorter on emission by a factor $(1 + z)$. As this radiation travels to us it will be redshifted by a factor of $(1 + z)$. The two effects cancel and the peaks all arrive at the same wavelength and hence reinforce to give a perfect black body curve.

However, the Doppler parameter results do not agree with this. According to the Doppler parameters the local universe is hotter than that further away. The temperature does not increase as $(1 + z)$ and so the peaks in the CMBR from different parts of the Universe would not coincide and the resulting curve would not be black body. In this scenario, the only way we can have a perfect Black body curve is if the CMBR is local.

7.5 Distribution of SNe Ia's in redshift space

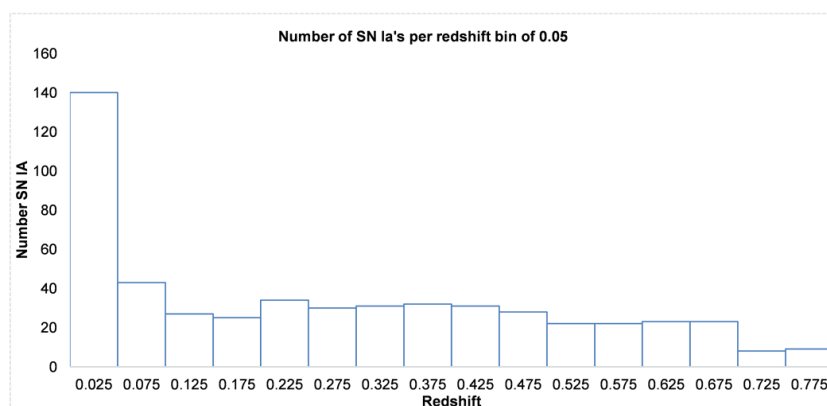
In looking for 'time dilation,' researchers look at local SNe Ia's where any 'expansion' effects should be minimal and form a template for the light curve. This is then compared with the more distant ones

which have broader light curves when compared to this. The assumption being that they are all the same. But how valid is this assumption?

One way is to look at the distribution of SNIa's with redshift. In an expanding Universe the Supernovae would have been packed into a smaller volume and the supernovae number density would be higher in the past at greater redshifts, reducing at smaller redshifts as the Universe expands. In a static Universe, we would expect the number of supernovae per unit redshift to be constant. The "Union 2.1" SNe Ia Compilation Magnitude vs. Redshift Table at the supernova cosmology project [27] gives a compilation of data from several datasets and includes 833 SNe drawn from 19 datasets. Of these 580 SNe Ia pass usability tests. The redshift was divided into 'bins' of size $z = 0.05$ and the number of supernovae in each bin was determined Fig 2. Note that there are far more supernovae in the closest bin $0 \leq z < 0.05$ than further out and apart from the closest two bins, the number of supernovae per unit redshift is fairly

Fig 2. Number-density evolution of supernovae Ia from the supernova cosmology project's Compilation magnitude vs. redshift table at the supernova cosmology project

constant suggesting a static universe. Furthermore, in looking for 'time dilation' workers make up a template from the closest SNe Ia's and apply it to the more distant ones. Is this valid when there is a discrepancy in the distribution? Could it be that there are far more SNe Ia's in the nearest bin because we don't see the dimmer ones farther away? If so we are back to a Malmquist bias as the template would be based on dimmer SNe Ia's which are known to have narrower light curves than the brighter ones seen in the distance.



In 2015 [20] observations suggest that there are two types of SNe Ia, labelled NUV-red and NUV-blue (NUV-Near Ultra Violet). At low redshift almost 70% of SN Ia's are NUV-red but at higher redshifts the percentages fall so that only 10% of SNe Ia's are NUV-red. Can any light curve template found from an average of nearby SNe Ia's be valid when applied to the more distant ones?

8. Discussion

It would appear that the main objection to Tired Light theories (that they would blur images) were based on a false model of the IGM. Due to galaxies boiling off electrons for many billions of years it must be full of electrons with the protons left behind and possibly forming 'Dark Matter.' Since the electrical potential energy of these electrons dominates their kinetic energy they will crystallise into a Wigner crystal on a BCC space lattice. Since the electrons are arranged in a spatially coherent way, photons of light interacting with them will travel in straight lines as they are absorbed and re-emitted and thus the image will not be destroyed but preserved.

FRB's provide a new and exciting window on the Universe regardless of what produces them as they enable us to determine a value for the mean electron density of the Intergalactic medium. Using the angular-diameter distance to the FRB gives $n \approx 0.350 \text{ m}^{-3}$ and the luminosity distance gives $n \approx 0.498 \text{ m}^{-3}$. Interestingly, the New Tired Light theory was first published in a peer reviewed journal in

2006 and in there and from that time onwards it has been stated that the mean electron number density will be found to be $n = 0.5m^{-3}$.

Having actual measured values for ' n ' enables us to determine the redshift of the host galaxy using New Tired Light and then compare this to the measured value. Using standard Physics, and published collision cross-sections we can calculate the redshift from first principles for two sample wavelengths (one in the visible and one in the UV) and both agree on a redshift of $z = 0.143$ which not only shows that predicted redshifts are independent of initial wavelength but agree well with the measured value of 0.19273 ± 0.00008 - a percentage difference of 26%. This assumed the wavelength remained constant during the journey - which it does not since it increases at every photon-electron interaction. To take this into account we would have to use the full exponential equation for redshift by New Tired light and this gives a value $z = 0.154$ a percentage difference of 20%. It should be remembered that in determining the DM of the IGM the maximum contribution from the Milky way galaxy was used. Should it be less than the maximum then our predicted value would be closer still.

In NTL, The energy transferred to the recoiling electron is re-emitted as secondary radiation which forms the CMBR. The wavelength of the radiation was calculated from first principles and found to be in the microwave region. Importantly, the radiation emitted by the recoiling electron on interaction with the UV photon of wavelength $\lambda = 5 \times 10^{-8}m$ has a wavelength of $\lambda = 2.1 \times 10^{-3}m$ which is the wavelength at which the CMBR peaks. If this occurs by chance then it is a truly remarkable coincidence. In NTL, the Hubble constant is given by $H = (2nhr/m)$ which, with $n \approx 0.498 m^{-3}$ from the luminosity distance gives $H = 2.04 \times 10^{-18} s^{-1}$ or $63 km s^{-1} per mpc$. This compares well with the most recent published value of $H = 70 km s^{-1} per mpc$ a difference of just 10%.

Should redshifts be due to a photon-electron interaction then there will be a direct relationship between dispersion measure DM and redshift z independent of distance and mean electron number density since these are common to both. The relation is found to be $DM = (mc/2hr)\ln(1+z)$. Substituting for the constants and including a unit conversion factor to reconcile the astronomical units of DM and the SI units of the left hand side gives $DM = 2380 \ln(1+z)$. This is the equation of a straight line through the origin having gradient 2380. Using the data from FRB121102 gives $DM = 1930 \ln(1+z)$. A difference in the gradient of 19%. We must remember that since we used the maximum contribution from our galaxy to determine the DM_{IGM} . Should the contribution be less than the maximum the two values would be closer. Since we only have one point for our graph we are unable to construct it but it will be an interesting graph to construct as more and more FRB's are discovered along with their DM and the redshift of host galaxy.

Up until recently, supernovae light curves and their alleged 'curve broadening' have been the only piece of evidence in support of an expanding universe. Quasar light curves show no 'time dilation' effects. Hydrogen clouds are evenly spaced implying a static universe and these same clouds are at the same distances as many of the supernovae purportedly displaying 'time dilation.' The Tolman surface brightness test applied over a large range of redshifts now supports a static universe and instead of the universe 'cooling down' after a 'hot Big Bang,' Doppler parameters from Hydrogen clouds show the temperature remaining the same or if anything, heating up! Now we see that looking at thlow and e raw data only and not calibrating them by a SALT2 or other analysis the light curves show no time dilation and overall agree with a static universe. Looking at the distribution of supernovae with redshift we see that there are far more populous at low redshift but from then on, evenly distributed as suggested by a static universe. This result suggests that a template formed on near supernovae is not valid when applied to distant ones. Furthermore it suggest perhaps a Malmquist bias is responsible for the curve broadening (if any). It would appear that now is the time to rethink our cosmologies in terms of New Tired Light and a static universe.

The presence of wigner crystals in the IGM answers an oft asked question – that is, 'if redshifts are due to a photon-electron interaction, why don't we get even larger redshifts in the dense plasmas within our own galaxy?' The question is partially answered in that the denser the plasma, the greater the forces acting between the electrons and so the plasma becomes 'stiffer' and this reduces the recoil. However, these plasmas are electrically neutral consisting of both electrons and protons. In this situation it is very difficult to meet the conditions necessary for the electrons to form on a BCC crystal lattice. The

temperature has to be very low and almost at absolute zero. In the dense plasma, the electrons do not crystallise and any interaction is by the Compton effect where the photons are scattered. Since the collision cross-section for the Compton effect is exceedingly small, most photons tend to pass through without interacting. When the conditions are right, the electrons crystallise onto a BCC lattice and redshifts are caused by New Tired Light. This is often the case in the IGM since the electrons and protons have been separated by the photo-electric effect at the edges of galaxies and there are only electrons present in the IGM.

Wigner crystals can be set up in the laboratory using a Penning trap. Although these are electrically neutral and so not the same as those in the IGM, a next step may be to look into the feasibility of creating a wigner crystal in the laboratory, fire a laser through it and look for a redshift.

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Acknowledgments.

The author wishes to thank all those who attended the presentation of this paper at the Vigier 11 conference in Liege 2018 and for their discussions and thoughts on how to improve the paper. I would also like to thank the organising committee without whom the conference would not have happened.