Gravitational Redshift of the Early Universe

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ABSTRACT

Current cosmological models of the universe are founded largely on redshift-distance measurements. Since Hubble first presented the Hubble diagram, considerable effort has been undertaken by astronomers to expand the data set. Here we contend that the redshift data has been incorrectly interpreted as a receding velocity. Interpretation of the data as a gravitational redshift enables the redshift-distance data to be fitted with a constant mass of 3 x 10^{11} solar masses. The accelerating universe, dark energy, dark matter and stretched space are not required. This interpretation suggests a static universe.

INTRODUCTION

Hubble first demonstrated that the nebulosities observed in the sky were galaxies like our own Milky Way. Large telescope observations combined with spectroscopy showed that the more faint the galaxies appeared, the greater their redshift. The observed redshifts were attributed to recessional velocities and the Hubble Law was created[1]. It is worth noting that Hubble was reticent to solely attribute the measured redshifts to a Doppler effect[2]. Our current understanding that includes the accelerating universe is based on measurement and interpretation of the redshift-distance curves, Hubble plots, that are interpreted as an increasing velocity with distance[1,3-5].

The "standard model" of big bang cosmology, the Lambda Cold Dark Matter (Λ–CDM) model[6] is founded on the recessional velocity interpretation of the redshift data from a century of observational astronomy[1,7-10]. Two foundational postulates of the model are the existence of Dark Matter and Dark Energy. Dark Energy in the form of the cosmological constant, Λ , is necessary to model the accelerating universe[3].

However, there exists an earlier body of data by Arp et al. that shows that the measured redshifts cannot be due to a Doppler effect[2,11-13]. There are a number of interacting galaxies and associated quasars that have significantly differing redshifts[13]. Essentially a single astronomical object has components with redshifts that differ from each other and that of the host galaxy. This effect cannot be due to rotation of the galaxy. Despite showing that the measured redshifts cannot be singularly attributed to recessional velocity, these results have been largely ignored by the astrophysics community[2,11-14]. A number of alternatives to recessional velocity are have been suggested by Arp[11-13] and Radcliffe[2]. Possibly the only effect that generates redshift that is consistent with all the observations and criteria outlined by Arp and Ratcliffe is that of gravitation. Apparent quantisation of the redshifts is also potentially explained by gravitational effects where the mass of the objects generating the redshifts is quantised. Several recent papers have also questioned the "standard" Λ-CDM model of cosmology in view of recent experimental data[15-17].

Here it is postulated that the measured redshift data of the early universe (high redshift) has been incorrectly attributed to a Doppler shift and receding velocity[1,6,7,9,10]. The observed redshifts in the early universe are attributed to an Einstein redshift also known as a gravitational redshift[18-20]. The data fits a gravitational potential.

THEORY AND ANALYSIS

The measured redshifts are composed of a Doppler and gravitational contribution:

$$z = z_D + z_G \qquad [1]$$

Where z is the measured redshift, z_D is the doppler redshift and z_G the gravitational contribution. In the early Universe, $z_D \ll 1$ and the measured value of z is equal to the gravitational redshift, z_G. as shown in Figure 1. In the local region of the later universe, $z_G \sim 0$ and z tends to the Doppler value as is observed in Figure 1 below. Figure 1 shows that there is a rapid increase in redshift at an effective brightness of approximately 14. In the local region of the Universe the redshift values are relatively small.

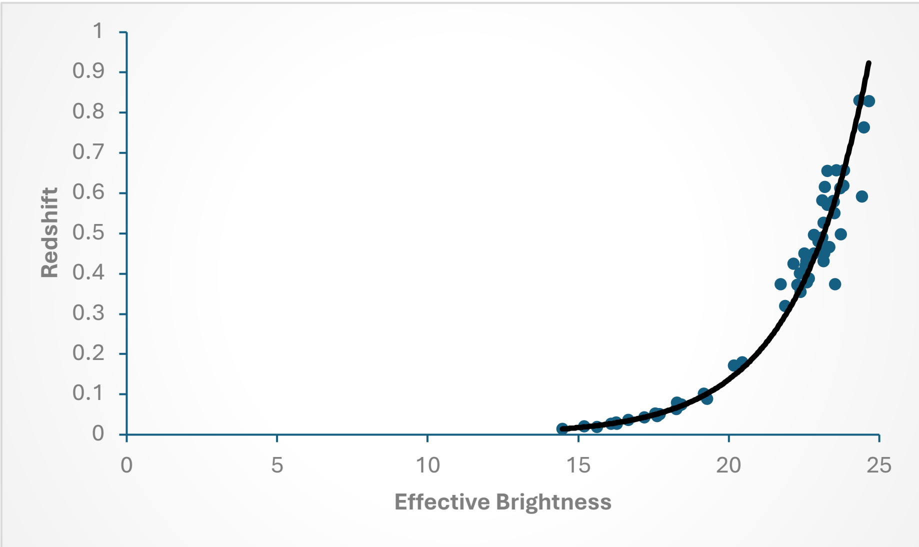

Figure 1. Measured redshift versus effective brightness data taken from Perlmutter et al. (REF). Note, Earth is at the origin with the data between zero and brightness 14 (not shown) being along the horizontal axis. The data presented by Rout shows that there is significant scatter in the redshift distance data in the local universe[2].

The Einstein redshift, otherwise known as the gravitational redshift, was first proposed by Einstein theoretically and has been observationally verified[18,20,21]. The gravitational redshift has been measured for a number of nearby astronomical objects including the sun[22] and a number of local cosmological objects outside the solar system at low redshift[23]. Indeed, the measured gravitational redshift has been used as confirmation of the theory of General Relativity[24]. The data presented by Rout shows that there is significant scatter in the redshift distance data in the local universe[2].

The data of Perlmutter et al. [7,8,25,26] Schmidt et al. [9] and the compiled data presented by Shirokov et al.[10] yield a relationship between the redshift and distance that follows a power law behaviour such that:

$$z \sim R^n \qquad [2]$$

Where z is the redshift and R the distance from the gravitational mass with n the power determined from the redshift data. Note that the brightness scale in Figure 2 is a logarithmic distance scale as detailed in the figure caption.

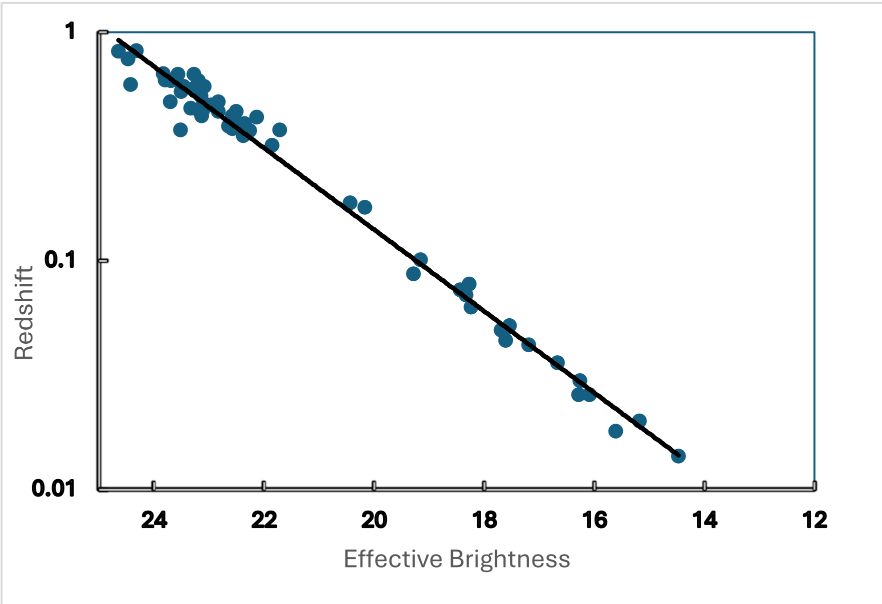

Figure 2. The data of Figure 1 presented on a logarithmic plot to show the linearity and fit. The slope yields a power law exponent of -0.90 +/-0.1. Effective brightness is related to distance by: $M_{eff} = 5 \log D_L + M_B$ where M_{eff} is the effective brightness, D_L is the distance and M_B the measured brightness as detailed in Perlmutter et al[8].

The data of Perlmutter et al. [8] yields n = -0.90 =/- 0.1 while that of Schmidt et al.[9] yield a value of n = -1 +/-0.1 (data not shown) for the R vs z^n while the higher redshift data presented by Shirokov et al.[10] yields a slightly lower number of n = -0.8 +/-0.1 (data not shown)

Uncertainty in the distance measurements has recently been discussed[27]. Measurement of SN 1a brightness as used by Perlmutter et al.[8] and Schmidt et al.[9] appears to be a relatively robust measure of distance. General Relativity shows that both length and time change in high field strengths. These changes while giving rise to a gravitational redshift should not modify the measured intensities[18-20].

Calculation of the general relativistic gravitational redshift for a spherically symmetric gravitating body has been shown to be of the form [18-21,28].

$$z = (1 - 2M/R)^{-1/2} - 1 \qquad [3]$$

Where M is the gravitational mass.

The Newtonian limit for the relativistic field is then:

$$z \sim MR^{-1} \qquad [4]$$

The data presented by Perlmutter et al.[8] and Reiss et al.[9] shows behaviour that obeys Equation 4 approximately with the power law exponent being -0.90 for Perlmutter et al and -1.00 for Schmidt et al. with a constant mass M of the early universe. The measured redshift data in the higher redshift region presented by Shirokov et al.[10] shows behaviour that is more consistent with equation 3 where the value of n = -0.80 deviates from the Newtonian limit as expected at ever increasing field strengths. While not being a complete proof of the gravitational redshift being dominant at these distances, it is strong evidence that the measured redshifts are of a gravitational nature. Furthermore, redshifts greater than 1 suggest velocities greater than that of light when attributed solely to a Doppler effect. “Stretched Space“ has been introduced to rationalize the observed z > 1 values[29]. The gravitational interpretation does not have this limitation and does not require the introduction of “stretched space” to rationalize the data.

The data is fitted by using a constant mass M of the early Universe that gives rise to the gravitational redshift. This is consistent with the mass of the early universe being very large compared to the mass loss due to emission of radiation with time. Conversion of matter to energy in the form of radiation should result in M decreasing at later times in cosmic evolution.

Assuming that the age of the Universe is ~14Gyr[17] to give an estimate of R = 0, the calculated gravitational mass giving rise to the redshifts is ~3 x 10^{11} solar masses. This value is significantly less than the estimated value for the mass of the Universe as 10^{22} solar masses[17]. The estimated mass is of order 10 to 100 times that of the largest black holes measured to date and at the theoretical limit of black hole size[30].

Data plotted over the complete range of redshifts shows that z is relatively small in the later universe where the gravitational effect of the early universe is relatively small as shown in Figure 1[7].

CONCLUSIONS.

Attributing measured redshifts to the gravitational potential of the early universe explains the observed increase in redshift with distance from observer and negates the need to introduce the concepts of dark energy, dark matter and stretched space. Furthermore, the data is well fitted by both general relativistic and relativistic-Newtonian limiting models using a constant mass of the early Universe with varying radius from the gravitational source. The agreement between the experimental data and the theoretical prediction is possibly the most complete confirmation of the theory of General Relativity to date. Interpreting the measured redshifts as gravitational redshifts also resolves the Hubble tension problem and negates the need for stretched space to account for z values greater than 1[31-33].

The Hubble tension may also be resolved using this interpretation of measured redshifts. A new model of the universe based on this understanding will be forthcoming.

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