Universe Investigation Based on Observation of Redshift

Jiahao Chen*

Saint Paul American School, Beijing, China

*Corresponding author: chen.jiahao@stpaulamerican.org

Abstract. Redshift interpretation in astronomy gives a significant quantity of information about the universe. However, the accurate explanation of the phenomena is surrounded by considerable disagreement. On this basis, this paper explores how the redshift came to be understood historically and summarizes the basic theoretical descriptions. To be specific, this study differs from several hypotheses about the cosmos, including Doppler effect, the Big Bang theory and some of its most prominent adversaries, and mention some of the outstanding issues. A few concepts not often linked with astronomy and astrophysics are also addressed with the intention that a wider perspective on this important issue might be studied. Nevertheless, scholars agree that the CMB is the ultimate limit. Before that time, the Universe was made of hot plasma, and light couldn't move in straight lines. It means that there is a limit to how far a redshift can go in theory. For further study, researchers should construct a picture of the cosmic architecture on very large dimensions by using the redshift. Overall, these results shed light on guiding further exploration of the formation of universe.

Keywords: Redshift; Doppler Shift; Expansion; Big Bang Theory.

1. Introduction

Redshift is a essential and contentious concept related to astronomy and the study of the universe. When it occurs, the electromagnetic energy that an item emits or reflects moves toward the lower end of the electromagnetic spectrum. It provides a starting point for seeking to comprehend aspects of the galaxy and even the whole universe. Different explanations for the measured redshift cast doubt on the reliability of the data. The ideas regarding the beginnings of the universe are an example in which this is particularly pertinent. The Big Bang model for the origin of the universe is now the most commonly accepted explanation for the origin of the universe among scientists [1]. However, The validity of the Big Bang model remains in question. The question of whether it is fair for one theory to receive so much praise while other hypotheses seem to be discarded without the same opportunity to complement and fix their flaws still requires careful consideration.

Newer studies using this connection at big redshifts have found that it weakens with higher redshifts, suggesting that it is changing through time [2]. The researchers looked for potential links between the redshift of GRBs and their apparent locations in the sky. At the "far GRB patch," nine distant GRBs show departures from randomness with a significance of 1%, suggesting that the sky and radial parts of the GRB distribution may be divided and both determined separately [3]. Zero in on the power-spectrum form of the anisotropy in redshift space and show how much modeling of the anisotropy in redshift space and the survey window function is necessary to identify this with certainty [4].

While there may be no absolute answers to these questions, an enlightened reader may be better able to decide whether or not to rely on "common knowledge" if they have a deeper awareness of the factors at play. This study aims to provide light on the origins of the redshift-distance link theory, Hubble's Law, and the Doppler effect, as well as their relationship to redshift, and their subsequent astronomical and cosmological interpretations. The "relativistic Doppler effect," Einstein's general relativity equations, Friedmann's equations, and gravitational redshift should all be covered here. After that is the disscusion about several worldviews and cosmological theories, including the role of cosmic redshift in these models. The Big Bang hypothesis, in particular, will be scrutinized because of its broad popularity in the scientific community. Other ideas (e.g., the Steady State theory) will be contrasted with it. Several potential explanations for the cosmic redshift will also be briefly discussed. Some of them, such as the Compton effect [5] and the intrinsic redshifts [6] and the fatigued light

theory [7] may be linked to theories of the universe's inception, but these will be investigated in more detail later on.

2. Redshift's Origins

The development of wave mechanics and the study of events related to the Doppler effect in the 19th century gave rise to the first cosmic redshift theories. Doppler provided the first scientific explanation for the phenomena, which is remembered by the name of this effect [7]. The Doppler effect is one that is often experienced, albeit the typical person may not completely comprehend what it is or even that they are experiencing it. Since sound waves are involved in the majority of instances of the phenomenon, this is the most typical explanation given for it [8]. A summary of the results is shown in Fig. 1.

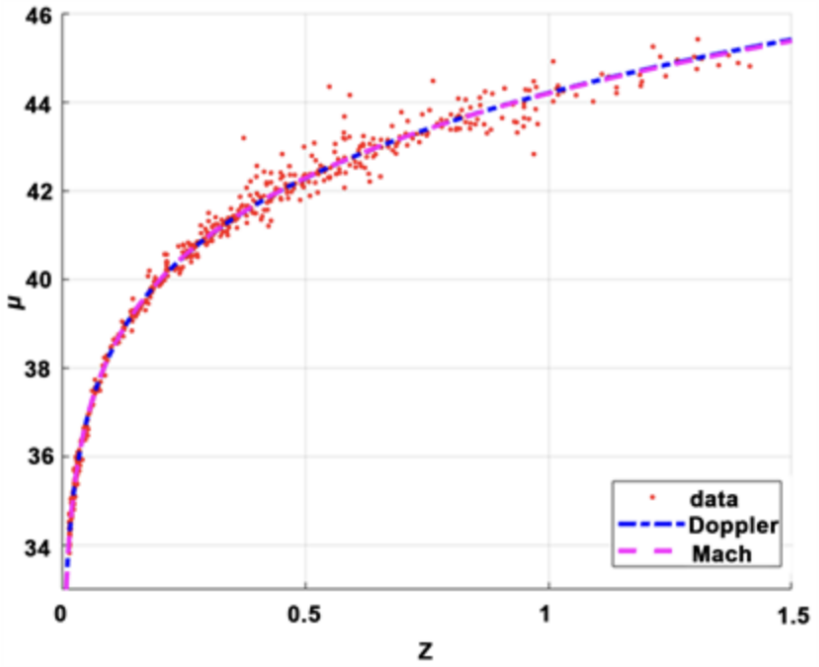


Fig. 1 Mass of the Universe and the Redshift.

Doppler assumed that all waves would be affected by this impact. It turns out that this forecast was accurate. Armand-Hippolyte-Louis Fizeau, a French scientist, first identified the Doppler redshift in 1848. Stars' shifting spectral lines, he concluded, were caused by the Doppler Effect [9]. The first person to use this approach to calculate the star's velocity departing from the our planet was British astronomer William Huggins in 1868. In 1871, optical redshift was confirmed by the observation of the phenomenon in Fraunhofer lines by means of solar rotation, at a wavelength of around 0.1 in the red. The American astronomer Walter S. Adams seems to have used the phrase "red-shift" in literature for the first time in 1908 when he refers to "Two techniques of exploring the nebular red-shift" [10].

Slipher first noticed that majority of nebulae that are spiral in shape had large redshifts in 1912. Then, in 1915, Einstein developed the equations that form the basis of general relativity [11]. For example, one considers the following equation:

$$G^{\mu v} = -\left(\frac{8\pi G}{c^2}\right) T^{\mu v} \tag{1}$$

The term on the left is the component of the Einstein tensor, which expresses the effect of gravity through the curvature of space-time, and the right describes the energy and momentum of "matter," with some familiar constants in front. Here, $G^{\mu v}$ is Einstein tensor which describes curvature of spacetime, and μ is energy-momentum tensor which describes distribution of the matter in the spacetime. This equation links spacetime geometry to the properties of matter and energy. It seems to be one equation is really 16 equations since each superscript represents one of the four spacetime

coordinates. These equations essentially explain the principles of conservation, such as the conservation of energy and momentum. Karl Schwarzschild solved these equations in 1916 [12]. The great majority of textbooks often refer to the Schwarzschild metric as

$$ds^2 = c^2\left(1 - \frac{2MG}{c^2 r}\right)dt^2 - \frac{dr^2}{1-\frac{2MG}{c^2 r}} - r^2(d\theta^2 + \sin^2\theta\, d\phi^2) \quad (2)$$

It depicts the geometry of spacetime around a mass M spherically symmetric object at spatial coordinates r = 0. Research into the perihelion advance of Mercury, the bending of starlight by the Sun, and the "gravitational redshift" (i.e., three tests of Einstein's general relativity) rely on this metric as its basis. Objects like the star and the planets are very nearly spherical, and this metric provides a good description of the spacetime geometry around them. Later, Edwin Hubble proposed Hubble's law after seeing a roughly inverse connection between nebulae's redshift and distance, similar to those seen by Slipher. This rule just asserts that a galaxy or other far-off astronomical object's redshift is proportionate to its distance. These findings support Alexander Friedman's 1922 research, which resulted in the renowned Friedman equations, a system of equations that regulate celestial objects. In the framework of general relativity, a homogeneous and isotropic model of the cosmos governs how space expands via a system of equations. This is common evidence in favor of the Big Bang hypothesis and is regarded as the earliest observable foundation for the expanding space paradigm. It is significant that Hubble always contended that the redshift did not necessarily indicate a rate of recession but may instead be produced by other reasons, even in his last address at the Royal Society.

2.1. Doppler Shift

If an observer is moving, the wave's frequency and wavelength will change, a phenomenon known as the Doppler effect [13]. The term "red shift" is used to describe the detection of a source's receding motion from an observer. Conversely, a "blue shift" is observed if the source is traveling toward the observer. If a light source travels away from an observer at a speed of v, then the value of redshift is demonstrated through z ≅ v/c, where c is the speed of light in a vacuum. The frequency of the source is unaffected by the recessional motion, but the typical Doppler effect gives the impression of a lower frequency.

Relativistic phenomena associated with the motion of sources traveling close to the speed of light are crucial to understanding the effect. As opposed to the "non-relativistic Doppler effect," which uses the propagation medium as a reference point in its equation, the "relativistic Doppler effect" uses the time dilation effect of special relativity. They are Lorentz-symmetric, which is required for explaining the observed frequency difference, and they provide a complete explanation [14]. To redo the redshift formula in a more convenient form, one obtains $1 + z = (1 + v/c)\gamma$. Since the Lorentz factor depends only on the absolute value of the velocity, the relativistic redshift produced is insensitive to the direction of the source's motion. The classical part of the formula, in contrast, is reliant on the projection of the source's velocity along the line of sight, and hence produces variable values depending on the direction of view. For an object moving at an angle to the observer (where 0 degrees is perpendicular to the observer), the full form of the relativistic Doppler effect is

$$1 + z = \frac{1+v\cos(\theta)/c}{\sqrt{1-v^2/c^2}} \quad (3)$$

This equation is simplified for motion simply along the line of sight (= 0°) as follows.

$$1 + z = \sqrt{\frac{1+\frac{v}{c}}{1-\frac{v}{c}}} \quad (4)$$

A redshift is a relativistic effect, and in the case when the emitter is moving at right angles (= 90°) to the detector, the relativistic redshift is called the "transverse redshift as:

$$1 + z = 1/\sqrt{1 - v^2/c^2} \quad (5)$$

This is achieved regardless of whether or not the target is vanishing from sight. If the source is moving toward the observer, the dilation will negate the expected blue shift at a certain speed, and at greater speeds, the source will be redshifted.

At first, the Doppler effect was thought to be the only possible explanation for the redshifts and blueshifts of extragalactic objects. However, theorists realized that the data might be intepretated by a different approach for creating redshifts when Hubble found an approximate connection between the growing redshift and the increasing distances of galaxies. Models of cosmology based on general relativity need Hubble's law, which states that distances increase as the redshift increases. As the Doppler effect explanation of redshift suggests, instead of a speed increase between an emitter and an observer being the consequence of a classical momentum and energy transfer, it might be due to some other phenomenon [15]. It is based on the idea that the distance that photons must travel causes an increase in both their wavelength and their redshift. Existing cosmological theories account for this occurrence by interpreting it as an external manifestation of the time-dependent cosmic scale factor a:

$$1 + z = \frac{a_{now}}{a_{then}} \tag{6}$$

Hubble Redshift" or "cosmological redshift" describes this phenomena [15]. As needed by the cosmological principle [16], the effect is large-scale isotropic owing to the expansion of intervening space, implying that galaxies are not receding merely due to a physical velocity away from the observer. At low cosmic redshifts (z<0.1), spacetime expansion is insignificant, and the observed redshifts are dominated by the peculiar motions of galaxies relative to one other, which cause additional Doppler redshifts and blue shifts.

Even though the Universe's expansion redshifts distant galaxies, astronomers sometimes call this recession velocity. Thus, Doppler redshift is used instead of cosmological redshift to describe the motion of galaxies dominated by spacetime expansion. The cosmological recessional speed will not match the relativistic Doppler equation. Due to Einstein's special relativity, v > c is impossible. In cosmic redshift, the distance between objects like quasars and Earth may increase faster than light, allowing v > c. Space expands faster than light because it is material-free. Change the coordinate system to see how distant galaxies are receding and the space between galaxies is expanding are related. The Friedmann-Robertson-Walker metric is needed to express this mathematically.

2.2. Big Bang Theory

The Big Bang theory is widely accepted as the best explanation for the Big Bang and cosmological evidence. It is the only explanation most people have heard of, therefore they tend to accept it without question. The typical individual is susceptible to embracing the big bang idea without question because of the human inclination to adhere to the status quo. If so many eminent researchers back this theory, then it must be correct. It's crucial to gain a firm grasp of the Big Bang hypothesis's origins, supporting data, and its flaws before diving headfirst into critique. When there are so many different hypotheses out there, it's outrageous that proponents of the Big Bang hypothesis are given carte blanche to explain away their flaws in this manner without being required to make any necessary adjustments to account for new astronomical and physical findings.

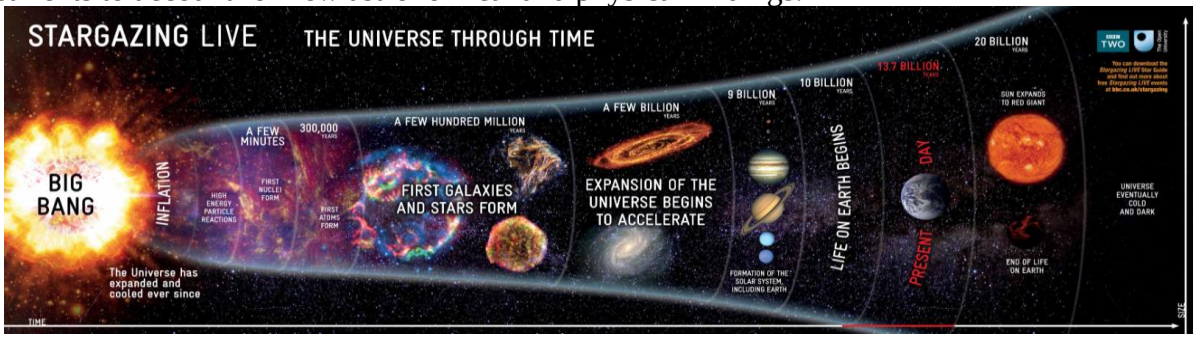


Fig. 2 A sketch of the Big bang theory.

It's also important to remember that the introduction of the cosmological constant was part of Einstein's biggest blunder, as it was part of an effort to create a theory of a static world. Already, it is being utilized to patch up the holes in the Big Bang theory (as sketched in Fig. 2). A thought that was abandoned because it did not suit the idea of an expanding cosmos is essential to a failed hypothesis. The issues with the Big Bang theory are too many to mention here. The big bang theory of the CMBR may be called into question by recent discoveries of "cold patches" in the background radiation. This is owing to the fact that "not only is the average approximately the same. Nevertheless, it is extremely distant from it, meaning that the size of the cold spot is nearly the same as anticipated for a flat, smooth universe.

3. Limitation & Prospects

At a redshift of 1100, the primordial hot plasma is composed of protons, helium nuclei, and electrons; this plasma is the source of cosmic microwave background radiation. The equipment can't see anything beyond the redshift because, as the redshift increases, the plasma becomes opaque owing to light scattering by free electrons. When the temperature of the plasma falls below 3000K, it becomes neutral and begins to emit radiation. The temperature has been redshifted 1100 times and is now 2.73K [16]. The universe is about 400 million years old, which corresponds to a redshift of 11 for the furthest galaxies.

The most distant galaxy discovered to date is GN-z11. Discovered in 2016 by the Hubble Space Telescope. To calculate how much GN-light z11's has been stretched by the expansion of the cosmos, researchers analyzed its redshift. GN-z11 has the highest documented redshift at 11.1, which is much greater than the 8.68 redshift found for EGSY8p7, the second biggest redshift for any galaxy [16]. Using the redshift, scholars may piece together the cosmic architecture at enormous scales. An example is the Hercules-Northern Coronal Wall, which delays light travel by nearly 10 billion years. In order to calculate the redshifts of millions of objects, the Sloan Digital Sky Survey is conducting a continuous redshift investigation. Data for the CFA Redshift Survey was initially gathered in 1982, making it the first known redshift survey.

One may be able to advance the age of the universe, maybe back to about 20 years, which is less than 200 million years old. This may be achievable thanks to the James Webb Space Telescope. It is thought that the initial galaxies or proto-galaxies evolved over more than 100 million years, implying z is larger than 30 years. Cosmological redshift drift might pave the way for the next stage in high-precision cosmic geometry studies as a direct and incontrovertible proof of the universe's acceleration.

4. Conclusion

In summary, this paper discusses the revolution of the universe from the persepective of cosmological phenonmenon. Specifically, cosmological redshift. Gallo44 pointed out that photons and neutrinos would have comparable redshifts if they were shifted by the Doppler effect and/or the spatial expansion effect, but they would have quite different redshifts if they were shifted by a non-Doppler process induced by energy-loss interactions. In light of this finding, an experiment is suggested that, if carried out, might provide a permanent solution to the issue. Moreover, the existing literature implies that astronomers and astrophysicists may gain much useful knowledge from individuals interested in plasma physics. When comparing the electromagnetic force to the force of gravity, it becomes clear how important it is for the two main schools of thought in astronomy and astrophysics to work together and look at the issues from all angles. In the end, many hypotheses, many of which will never be confirmed or disproven to everyone's satisfaction, e.g., the theory that a star's life history can be predicted with 100% accuracy. Therefore, transparent cooperation and communication are crucial to making enough advancement. Starting with a fresh look at the redshift issue is crucial. Overall, these results offer a guideline for the understand of the history and future of the universe.

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