the general science journal

"Big Bang Theory: History, Description, Assessment "

By Randy Wells

Applied Physicist and Independent Researcher in Theoretical Physics

Key Words: cosmological redshifts, plasma redshifts, ΛCDM cosmology, Big Bang theory, universe acceleration, dark energy, intrinsic redshifts, dark matter, cosmic microwave background

Abstract

For a number of decades now, a vast majority of physicists have held to what is called the Big Bang theory (BBT) of the universe, encompassing its beginning and development over what they claim to be 13.8 billion years. In light of recent observations from the Hubble Space Telescope (HST) and James Webb Space Telescope (JWST), this theory is not holding up very well. In this paper, I cover these and other issues. I have written at length on the BBT in [1]. In that paper I focussed on problems with an expanding universe model. Now I will address in greater detail other aspects of the BBT model in more detail. To set the stage, I begin with a bare bones description of the the BBT model. Also provided are brief bios and key contributions provided by both major proponents and critics of BBT. This is followed by a breakdown of dominant issues related to the BBT model. Finally, I conclude with final thoughts and a suggestion for how we should proceed in cosmology development.

Overview

A cosmology is a structured framework built for the purpose of understanding the universe by combining large scale astronomical observations, laboratory experiments, and models from physics and supporting mathematics. The cosmology associated with the BBT is called Lambda Cold Dark Matter (ΛCDM) and is currently the only widely accepted cosmology, or mathematical framework, in the mainstream physics community. Lambda, the Greek letter, Λ, symbolizes the cosmological constant, which mathematically represents the theorized cause for the expansion of the universe, believed to be some form of energy, dubbed "dark energy". Unobservable, hypothesized matter, or cold dark matter, is assumed to be the substance that appears to hold the universe together gravitationally.

There are basically five main theorized stages assoiciated with BBT [2]. In this article, I provide descriptions for each stage, including 1) inflation, 2) afterglow (or ionic recombination), 3) dark ages, 4) large structure formation, and 5) expansion due to dark engergy.

History

In keeping with the scope of this paper, I limit the content as much as possible to the BBT. However, some context is required to set up the cosmological views at the time of its introduction, as well as a few competing theoretical views along the way. There have been many contributors to the BBT development and advancement. There have also been many critics. What makes this paper unique is that there is at least an attempt to show both sides fairly. In this section I provide short paragraphs related to each of these. Additionally, several of these will be mentioned again later as I address the various hypotheses, related observations, interpretations, and theories that have evolved, relating to the BBT.

Prior to, and in the early days of, the BBT development, the cosmology most physicsts favored was the steady-state, or "static universe". A beginning for the universe was neither required nor hypothesized. Uniformitarianism reigned supreme during this era. Astronomical observational data was also limited to distances within our own galaxy. It was believed by most physicists that space is filled with an invisible substance called ether. However, after the historical Michelson-Morely experiment, in combination with Einstein's theoretical work in relativity, the ether model was abandoned by most physicists and the model that was accepted and installed in its place was Einstein's special relativity theory (SRT) and general relativity theory (GRT). Such was the consensus, whether or not is was a valid interpretation.

Vesto Slipher

Although not nearly as publicly known as some of his successors, especially Edwin Hubble, Vesto Slipher, an American astronomer, working at the Lowell Observatory in Flagstaff Arizona in the early 1900's is acredited as being the first astronomer to discover redshifted light from distant objects in space. Slipher developed a radio spectroscopic method for measuring in the infrared region of the electromagnetic spectrum. In 1912, he documented his experimental and analytical results, showing redshifts from light emitted by planets and galaxies [3]. Interpreting these redshifts as Doppler shifts, he calculated the speeds at which the objects appear to be receding. This obviously planted the seeds for the development of the BBT. His observations also included spiral galaxies.

Carl Wirtz

A few years after Slipher's published paper [3], Carl Wirtz, a German astronomer, also observed redshifts from planets and nebula [4], along with rotating spiral galaxies. In his work, he utilized what he called "K corrections" to compute the visual magnitude of an object in a wavelength region different from the region in which it was measured [5].

Albert Einstein

Initially, Einstein he was against the BBT model's expansion hypothesis, with a strong belief that the universe was static. In the development of his SRT and GRT equations, Einstein relied strongly on the work and mathematics of Newton, Mach, Lorentz, Minkowski, and others. When Hubble made his discoveries on Mt. Wilson, Einstein became a believer in an expanding universe. The irony of this is that Hubble was not, and never appeared to be, totally convinced the redshifts were due to expansion. Prior to this, Einstein had introduced a term in his GRT field equations to assure the universe is static. There was no empirical evidence to substantiate this factor. With the observed redshifts of distance galaxies, increasing with distance, it was later revived to symbolize what has been determined to be an accelerated expansion of the universe. The term became known as the cosmological constant, Λ. Einstein's GRT equations are the foundation for the expanding model of the universe [6].

Alexander Friedmann

Early in the 1920's, a Russian cosmologist/mathematician and early pioneer of the expanding universe model, used Einstein's field equations to derive two independent equations that are named after him [7]. These are provided and discussed later in this paper. From these equations, along with Hubbles discoveries, he made a strong case that the universe is expanding. Friedmann also played a key role in the development of the Friedmann-Lemaître–Robertson–Walker (FLRW) metric, one of the critical mathematical constructs used in BBT.

Georges Lemaitre

Many refer to Georges Lemaitre as the father of the BBT. He was a Belgian Catholic priest who was also a brilliant physicist. A contemporary of Friedmann, Einstein, and Hubble, Lemaitre solved Einstein's field equations, deriving the mathematics for an expanding universe as well as the redshift vs distance relationship similarly to Hubble. Years later he was given credit for these discoveries and his name is included in key developments such as the Friedmann-Lemaitre equations, FLRW metric (where the "L" stands for Lemaitre), and the Hubble-Lemaitre Law. It was Lemaitre's desire, in keeping with his Biblical beliefs, to show the universe had a beginning [8].

Edwin Hubble

Although not the first to discover galactic redshifts nor their relationship to distance, Edwin Hubble's work received the most publicity and acceptance within the physics community. Hubble, a former WWI soldier in the US Army, returned home to become perhaps one of the most famous astronomers. His most noted accomplishments were his recorded observations made in the 1920's on Mt. Wilson, where he used similar methods, or adopted from Slipher and Wirtz. Plotting the redshifts on a graph versus distance, he established what became known as Hubble's Law (later changed to the Hubble-Lemaitre Law due to the concurrent work done by Georges Lemaitre [9]).

Fritz Zwicky

In the 1930's, a Swiss astronomer named Fritz Zwicky, working at Cal Tech in Pasadena, California, made a key contribution to the BBT. He observed hundreds of galaxies and applied the measurements to the virial theorem, along with Doppler measurements. His conclusion was that the directly observed mass was much less than expected and that the velocities of the stars orbiting the centers of spiral galaxies did not obey Newtonian physics. This led to the belief there must be unobservable matter. It was dubbed "cold dark matter" (the "CDM" in the ΛCDM cosmology). Zwicky also made many contributions in the discovery of super nova and neutron stars. However, he was skeptical regarding universe expansion because the early recession velocities calculated for some galaxies were very high. He proposed "tired light" to be the cause of the redshifts rather than recessional speed [10].

George Gamow

A major contributor to BBT, George Gamow was a Russian protege of Alexander Friedmann in the 1920's at the University of Leningrad (now Saint Petersburg State University) . He was one of the first to apply the Friedmann-Lemaitre equations to promote the theory of an expanding universe. Uniquely combining quantum mechanics with relativity, he proposed the hypothesis that at the origin of the universe, radiation dominated over matter. He is well known for his work in radioactivity, especially alpha particle decay and quantum tunneling. Gamow also advanced the development of physics in the area of star, galaxy, and planetary system formation theories [11]. In 1934, Gamow and his wife moved to the United States where he took a professorship at George Washington University in Washington DC.

Fred Hoyle

Perhaps one of the most famous astrophysicists, Fred Hoyle, a student, professor, and director at Cambridge became very interested in star formation in the early 1940's. He worked with a team at Caltech to develop an area in physics known as stellar nucleosynthesis [12], how stars are formed and sustained. Hoyle and his colleagues determined through observational analysis of many stars that elements heavier than hydrogen and helium (such as iron) could be formed by nuclear reactions. His contribution to BBT was that of providing acceptable models for star and galaxy formation. However, he did not concur with key assumptions on which BBT theorists were basing the foundations of their model. These were mainly assumptions related to the origin of the universe. Hoyle is the one who jokingly dubbed the name "big bang," not by any means as a complement yet it stuck.

Penzias and Wilson

In the 1960's, two young engineers, Robert Wilson and Arno Penzias, just out of graduate school, were hired by Bell Labs to make some sky brightness measurements with one of their large horn radio telescopes. They surprisingly found that, regardless of where they pointed the telescope, they received microwave signals of significant strength with nearly the same frequency. Their initial thoughts included such possible causes as self noise from the electrical system, antenna effects, some atmospheric effects, and even from sources generated in nearby New York City. After much work, each of these possible sources were eliminated. Their observations resulted in a continuous measurement of microwave radiation with a wavelength of 7.35 cm and a temperature of about 3 K. They contacted expert researchers in radio astronomy at Princeton University such as Robert Dicke and Jim Peebles [13], who were already searching for what Wilson and Penzias discovered. They called it the cosmic microwave background, believed to be a remnant of the hypothesized big bang event. The Princeton team also conducted ground measurements of the phenomenon but at different frequencies.

Roger Penrose

Roger Penrose, a Cambridge alumnus and currently an Oxford professor is known mostly as a Nobel Laureate in mathematical physics. He shared a Nobel Prize in 2020 for his mathematical proof that Einstein's general relativity leads to the the existence of black holes[14]. Penrose developed novel mathematical and graphical methods that aid in understanding black holes. With these techniques, such as the Penrose Diagrams, one is able to reduce complexity in solving physics problems where infinity and singularities are involved. His career has spanned over several other topics in mathematical physics and cosmology. Currently, Penrose is one of major leaders in the multiverse hypothesis. He has expressed skepticism with the cosmic inflation hypothesis and favors the idea of universes repeating cyclically. Penrose has also expressed skepticism related to the existence of dark matter. With these views in mind, I would tend to consider Penrose a critic of ΛCDM and BBT in general, even though he is a strong proponent of black holes.

Halton Arp

Halton Arp, a prodigy of Edwin Hubble, was far from convinced that the observed galactic redshifts should be interpreted as recession velocity. His observations on Mt. Wilson led to the discovery of quasars. He observed that cosmic objects in the same galaxy exhibited vastly different redshifts. Eventually, he was not allowed any viewing access to the telescope. Arp, along with his colleague, Jayant Narlikar, co-authored 1993 paper [15], where they laid out their claims and rationale, heavily supported by observational data, that quasars are created and ejected by parent galaxies called active galactic nuclei (AGN's).

Stephen Hawking

In the 1960's, there was a brilliantly intelligent physicist, a prodigy studying under the famous Nobel Laureate, Roger Penrose at Oxford. His name was Stephen Hawking. Sadly, in his early twenties, he was diagnosed with amyotrophic lateral sclerosis, known as ALS, which is a nervous system disease that affects nerve cells in the brain and spinal cord, causing loss of muscle control and is known to get worse over time. Although this disease was physically debilitating for Hawking, it did not stop him from pursuing a deep understanding of the nature of the universe. He accomplished many things over his decades long career. Hawking contributed to a mathematical understanding of black holes, working hard to bridge the gap between quantum mechanics, in which time is well defined, and general relativity, where it is an elusive parameter [16]. Perhaps one of the accomplishments for which he is known is Hawking Radiation [17] which involves a separation of virtual particle pairs at the rim of a black hole. At the end of his career, Hawking was a key contributor to string theory, inflation, and the multiverse cosmology [18].

Alan Guth

Perhaps one of the most well-known contributors to the inflationary theory that supports BBT as the "bang" that kicked off the "big bang," was Alan Guth. He is an MIT trained (and currently MIT employed) American particle physicist whose main scientific interest has been the theory of the universe inflation. This theory (actually hypothesis) was welcomed by mainstream physics because it has served to provide some sort of explanation for the "smoothness" of the cosmic microwave background (CMB), an observation that was far from consistent with the conventional BBT [19]. I have provided a detailed description of the CMB, along with its interpretation issues in [20]. More information regarding universe inflation is provided later in this current paper.

Eric Lerner

Perhaps one of the major contemporary critics of the BBT, Eric Lerner is also a key proponent of a plasma cosmology, known as the "plasma universe." , Lerner rejects the conclusions mainstream physicists have drawn from astronomical observations. He is mostly known for his book, "The Big Bang Never Happened" [21]. Lerner has also authored many papers on this subject along with plasma physics, including peer reviewed papers in prestigious journals [22]. In [20], I included discussion on Lerner and his work in which he methodically and scientifically broke down the universe expansion hypothesis by subjecting it to widely accepted cosmology tools such as the Tolman Test.

Pierre-Marie Robitailli

A professor of radiology at Ohio State University, Dr. Piere-Marie Robitailli, was responsible for developing the first ultra high field clinical magnetic resonance imaging (MRI) system. Although neither an astrophysicist nor a cosmologist, Robitailli comes highly trained in physics, engineering, spectroscopic analysis, image processing, and signal processing. Dr. Robitailli has advanced a very strong case that the interpretation of the CMB should not be linked to the cosmos but is actually generated from a combination of the earth's oceans and nearby galactic radiation. In fact, he shows that blackbody radiation can only be emitted from a substance that can absorb all frequencies of electromagnetic radiation. This does not include matter in a plasma or gaseous state. Furthermore, according to Kirchoff's Law, a system must be enclosed within a solid container and exhibit thermal equilibrium before it can emit any blackbody radiation [23, 24, 25, 26].

Paris Herouni

A very large terestial telescope, known as the ROT54, or Herouni Mirror Radio Telescope, is a Soviet development, proposed, designed, and used by a Soviet astronomer named Paris Herouni. This telescope was built in the 1970's and early 1980's. It was operational from 1987 to 1990 and 2010 to 2012 (after it was modernized with current technology). The ROT54 has a primary spherical mirror with a diameter of 54 meters. Fixed in the ground, this hemispherical mirror, along with the secondary mirror and structure, was designed to allow no microwave diffraction to enter into the area of detection sensitivity. Such a design shields all the microwave radiation generated by earthly sources such as the oceans. Self noise on this antenna was determined to be precisely 2.6 K. Herouni could not detect any of the supposed 2.7 k CMB. Although his work was not accepted by mainstream physicists, no one was able to dispute his legitimate claim that a cosmic-sourced microwave background must not exist [27]. If it did, he would have measured it.

Wallace Thornhill

Wallace ("Wal") Thornhill, a plasma physicist who recently passed away, was perhaps one of the most well known among the critics of the BBT. A leader in what is called the "electric universe" cosmology, Thornhill focussed on plasma research similarly to others such as Velikovsky, Arp, Alfven, Scott, Sansbury, and Peratt. They demonstrated through laboratoy experiments and astronomical observational data that the universe is driven orders of magnitude more by electromagnetic forces than by gravity, as is the case for BBT. According to the BBT, all matter eventually forms in clumps that become bigger clumps due to gravitational attraction, admitting that the model does not consider gravity as a force but a phenomenon caused by curvature in a mathematical, imaginary grid called the spacetime continuum. Throughout his career, Thornhill has contributed much to the advancement of the electric universe in books such as [28], articles [eg., 29], technical papers [eg., 30], and documentary videos.

Big Bang Theory in Stages

I would like to reiterate that there is a difference between an hypothesis and a theory. A hypothesis is an idea proposed and needs to be demonstrated through experimentation and empiracal observations. Once the data is analyzed, the question is asked, "Is the hypothesis under test supported substantially by the outcome of the experiment?" If so, it is identified as a theory. This is a rough description of the scientific process. Interpretation of the data plays a critical role in this process. Unfortunately, this process has been abused over recent decades by forcing the data to agree with the hypothesis with the justification that it must also agree with a presupposition that the current popularly held assumption (e.g., the univese is expanding) is true. Consequently, if the outcome is not what was expected, new parameters (e.g., the cosmological constant), six more dimensions as in string theory, (also mislabeled as "theory"), entities (e.g., dark matter, dark energy), and more hypotheses (e.g., inflation). Therefore, as a reminder to the reader, the "T" in BBT is loosely inferred and, perhaps should be an "H".

Now that brief introductions of the key players for and against the BBT have been provided, along with an overview of BBT, and a reminder of the requirements for what a theory actually states, we will explore some of the salient aspects of the various stages "currently" associated with the BBT.

Cosmic Inflation

In the early phases regarding development of the BBT, it was plagued with several issues. With the application of GRT, the origin of the "big bang" resulted in a curvature singularity, meaning that, at the very instance of start of the universe, gravity would have been infinite. Furthermore, astronomical observations were far from what one would predict with this model. When the CMB was observed, it was determined that the early universe was much more smooth than was expected, regarding the spatial distribution of structures such as galaxies and clusters of galaxies. A third problem was that of violation of the speed of light related to communication of information across the diameter of the universe. To round it off with a fourth issue – no observed magnetic monopoles as was predicted. These issues led to one of the first major "fixes" to the BBT, now known as Inflationary BBT. There is currently a relatively new topic in modern cosmology referred to as "eternal" inflation. This leads to many other universes besides our own, as part of the multiverse model. I will not be addressing eternal inflation in this paper but plan to cover this topic in a future paper.

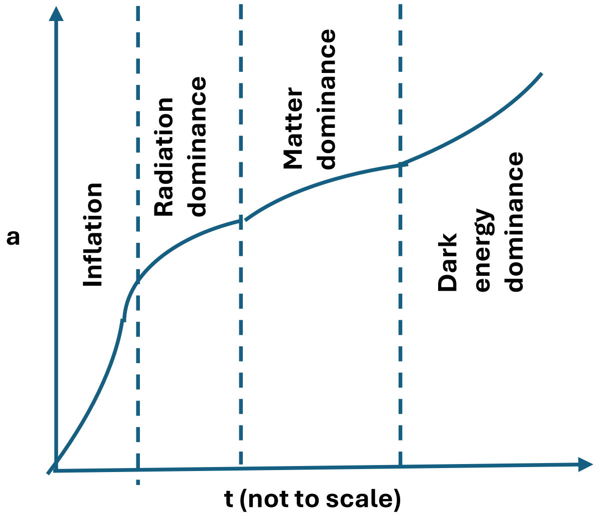

Figure 1. Rough sketch of scale factor time history.

First of all, the proposed cosmic inflation hypothesis to which most attribute initially to Alan Guth [19], was advanced partly to address the question of the unexpected smoothness in the CMB as well as the other issues mentioned in the previous paragraph. Hundreds of models similar to that of Guth have been proposed, included more of his own. This added on phase, designed to fit the CMB observations, has its origin placed in time, a fraction of a second prior to what has been referred to as the big bang. From this new point, what we call the spacetime grid expanded exponentially by a factor of 10^{26} in about 10^{-32} of a second (ie., less than a billionth of a billionth of a millionth of a microsecond).

No one knows what exactly causes this expansion. The most common inflationary cause model assumes some sort of scalar field. Various fields have been proposed. At one time, the Higgs field was popular but it was realized that such a field would actually hinder inflation through interactions. A current popular candidate is the "inflaton particle field". Much work needs to be done to mature this concept since it is linked to string theory (it is usually referred to as as a theory but should really be called the string hypothesus since it is purely mathematical, involving ten or more dimensions). Inflatons have never been detectected since the only ones that are assumed to have ever existed are what caused the expansion. This leads to the conclusion that they must have rapidly decayed or the universe would have continued inflating.

As was alluded to earlier, although the observed CMB appears to be very smooth, there are some anistotropic regions that appear slightly hotter and some slightly cooler than the average overall temperature (2.7 K). These are believed to be caused by spatial variations in the scalar quantum field during the inflation stage. However, the smoothness one would expect to occur from the stretching effect of inflation is only limited to a classical physics understanding. Steinhardt [31] has shown through thousands of Monte Carlo computer simulations, in which quantum physics effects are included, that the result is far from smooth. However, when a prior period of gradual universe contraction was simulated, Steinhardt was able to show that, even with quantum physics effects, smoothness is once again attained. Because of Steinhardt's work and others in this research area, there is becoming within the established modern cosmology arena, a consensus regarding cyclic universes, or multiverses(with Penrose as one of the leading proponents). Such a model would provide for the slow contraction phase such as the one Steinhardt simulated.

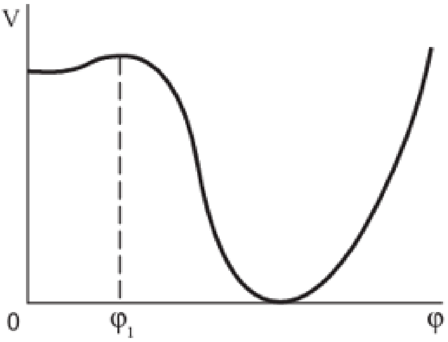

Figure 2. Hypothesized inflation potential curve

Now the question is "How did inflation terminate?" It is assumed that at the start of inflation, the quantum field, posessing a scalar value, call φ, had a potential energy, V. As φ increased, there was a drop in its energy as shown in Figure 2. Think of this low point in the curve as the lowest point on a roller coaster track, where as the starting point is much higher. Once this lowest point is reached there is no more potential energy (only kinetic energy remains). It is at this point that inflation is assumed to have stopped and expansion (an extremely slower stretching than inflation) began. One must realize that these lowest points in the curve varied across the surface of the univese, giving rise to variations in spatial energy density.

According to most inflation models during this transition process, whatever the quantum field consisted of during inflation, morphed into a myriad of other types of quantum fields such as those associated with quarks, electrons, protons, and photons. At this point, according to BBT, the universe was extremely so hot due to the high kinetic energy of the particles, along with super high densities that light was opaque due to constant scattering of photons by collisions with particles.

Before moving on to the stage succeeding cosmic infation, I would like to revisit the problems for which the idea of inflation was proposed. Recall that the inflationary stage was added to the BBT to address certain issues. The singularity of curvature issues was resolved by the application of quanum physics in the place of relativistic physics during inflation. The smoothness and flatness observations could now be understood as the result of inflation to the scale of 10^{26}. There was also the concern of communication across the diameter of the universe at the end of inflation since it would require speeds much greater than the speed of light. Although this is a very abstract concept, one could imagine the communication occuring throughout the process instead of waiting until inflation stopped. As far as lack of observed magnetic monopoles, it could be that they are merely unobservable due to extremely small densities as a rsult of the area expanding roughly by the square of the 10^{26} factor. This would mean that if, for example, there were originally 1 million magnetic monopoles the probability if detecting one would be less than one in 10^{46}.

Afterglow (or Ionic Recombination)

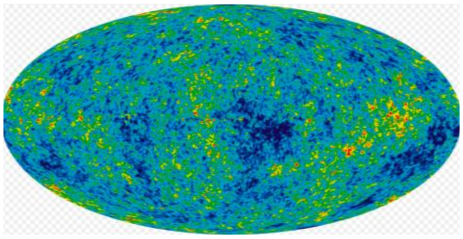

Figure 3. WMAP temperature map of the cosmic microwave background

As stated in the previous section, at the end of the inflation stage, the universe is considered, according to BBT, to consist of an extremely hot mixture of radiation and very high energy particles such as electrons and quarks. According to this model, quarks combine in triplets by gluons to form baryons such as protons and neutrons. This mixture is believed to be of very high density, so high that radiation could not penetrate through, making the universe very opaque. However, as the universe expanded, much more slowly than in the inflation period by many orders of magnitude, there was a universal cooling that allowed the quarks to form baryons and eventually, electrons to be captured by protons to form neutral hydrogen atoms. When this occurred, light could finally break through, unhindered. Hence the name given for this event is “The Surface of Last Scattering”. It is believed by most physicists that this moment is captured as in a photograph in the CMB (see Figure 3) and is estimated to have occurred around 375,000 years after the end of the inflation period.

The temperature at which electrons were able to combine with baryons to form atoms is estimated to be around 3000 K. This epoch has been given the dubious name of ionic recombination”. It is somewhat of a misnomer since there is no familiar hypothesis claiming there ever was a prior ionic combination. That aside, back to the temperature estimation. The CMB is measured to be at ~2.7 K. As was shown in [1], since the universe expansion scale factor, “a”, is inversely proportional to the absolute temperature, there must have been an expansion scale factor of about 1100 from the time the the light was emitted until the time it was received, resulting in a cosmological redshift, z, of about 1100.

In the short time between the end of inflation and moment of last scattering, baryonic particle density is considered to be so high that they provided a temporary medium for propagation of acoustic waves known as baryonic acoustic oscillations (BAO’s). BAO’s are assumed to represent spatial and temporal variations in quantum field energy density. Observable large structures such as galaxies and cluster of galaxies are believed to have been derived from these BAO’s [32].

Dark Age

Following the "Afterglow" or "Ionic Recombination", we move into a period called the "Cosmic Dark Age", "Dark Ages", or "Reionization". It is believed that during the first 50,000 years of this period, the expansion of the universe was domnated by radiation: photons and neutrinos, followed by matter dominance for the balance of the dark age (see Figure 1). Due to expansion after the surface of last scattering (CMB emission), the wavelength of the emitted light was greatly redshifted well beyond the window of detection with the human eye. It is estimated, according to BBT, that it would take another 400 million years before the first star would form and provide the first source of visible light. This progression of developments is illustrated in Figure 4, taken from [33], with the time axis at the top going from right to left and the red shift expression (1 + z), descending from the right to the left. We can see the redshift of about 1100 for the surface of last scattering. Moving ahead in time (moving towards the left in the graph), the universe cools at it expands, allowing for ions to form atoms (ionic recombination). As stated previously, we see the first stars forming about 400 millions later. For the BBT model, stars are assumed to form by gravitaional attraction. This is the driving factor behind the assignment of hundreds of millions of years to this period.

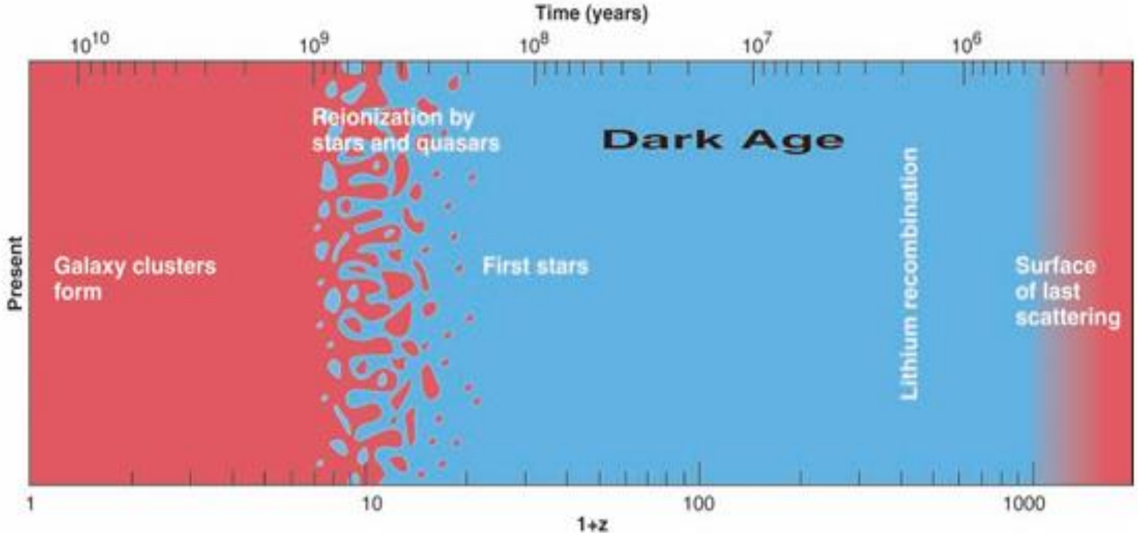

Figure 4. Progression of star and galaxy formation during the "Dark Age"

As mentioned earlier, Fred Hoyle[34] and George Gamow[11] were key pioneers, along with their predecessor, James Jeans[35], in the development of gravitational star formation models that are accepted within the BBT framework. Brief descriptions of star formation models are provided in [36]. The ΛCDM star formation model assumes gravitational attraction of baryonic matter into clumps due to variations in the matter and energy density. These clumps are then attracted to each other gravitationally, forming both CDM "halos" and baryonic matter stars. As the stars form and become more massive, their inner cores are subjected to tremendous inward directed pressure. From the pressure comes intense heat that is strongly correlated to the stripping of hydrogen atoms into ions, hence the other name for this peiod, "reionization". This plasma, consisting of free protons, neutrons, and electrons interact and fuse into hydrogen atoms, fuses into helium atoms and yield radiation pressure, as in a nuclear fusion reactor to balance out the inward gravitational pressure. With stars forming in this matter, the visible light returns to the universe and leads the way out ot the “Dark Age”.

Large Structure Formation

As stars were assumed to aggregate together over millions of years into clumps, the clumps combined with other clumps to form what we now call galaxies (when observations were first made they were all called nebula and some still retain the name). Galaxies are made up of stars, planets, moons, dust, and gas. Some are believed to contain black holes in the center. They are observed to take on various forms as descriped in a taxonomy accepted, with all its flaws, in what is called the Hubble sequence [37]. Classified according to shape, there are the elliptical galaxies, normal spirals, barred spirals, and irregulars. The BBT expected time required for a mature galaxy to develop gravitationally is in the hundreds of millions of years.

Not long after the early telescopic and spectroscopic measurements of spiral galaxies were made, it was observed that objects in the outer regions rotate at rates much higher than expected, defying Newtonian mechanics. It was determined that the visible matter, by itself, could not account for this phenomenon. As mentioned earlier, this led to the belief there must be unobservable matter that could only interact with observable matter via gravity. As already discussed, this invented substance was dubbed “cold dark matter”. Fritz Zwicky played a leading role in this area by showing mathematically how CDM could cause the unexpected outer rotation rates[38]. Dark matter is also used to predict such things as galaxy formation and gravitational lensing, CDM is modeled as a structural free parameter in computer simulations that are limited to very large scale resolution.

Accelerated Expansion

We now focus on the final and current phase in the ΛCDM cosmology, accelerated expansion. Space expansion is no longer dominated by matter (baryonic and CDM) but by something else. This “something else” has been given the name “dark energy”. Much research has been done through the observation of high Z galaxy distances of Type 1a supernovae that has resulted in the claim that the universe has reached the dark energy-dominant phase of expansion. The most noted physicist in this area is Dr. Adam Riess [40]. Once again the redshift observations were interpreted to be cosmological.

Serious efforts were made within the cosmology community to determine the source and nature of this dark energy. A hypothesis was advanced that it was due to the known quantum vacuum energy already observed in such experiments as the Casimer Effect [40] and the Lamb Shift [41] but this was dismissed due to an orders-of-magnitude difference between the predicted and observed acceleration. Furthermore, it was assumed that this dark energy density remains constant even as the volume of space increases. This is referred to as De Sitter space and is represented as the final segment of the curve in Figure 1.

With a carefully selected value (10^{-123} [42]) for the cosmological constant, Einstein's field equations were used to model the observed and subsequent interpretation as accelerated expansion. This can be shown in the Friedmann equation as follows:

$$\frac{\ddot{a}}{a} = -\frac{4\pi G}{3}\left(\rho + \frac{3p}{c^2}\right) + \frac{\Lambda c^2}{3}$$

where : a is the cosmological scale factor, $\ddot{a}$ is the acceleration of the cosmological scale factor, G is the Newtonian constant of gravitation, Λ is cosmological constant (with dimension length^{-2}), and c the speed of light in a vacuum. Parameters ρ and p are the volumetric mass density (and not the volumetric energy density) and the pressure, respectively.

Cracks in Big Bang model

In all fairness to the brilliant developers of the BBT (who deserve the hightest respect) for they have done much hard work that has led to the support and advancement of the ΛCDM cosmology and an understanding of the universe as has been briefly described in this article, I would now like to address several issues and mispredictions that cast strong doubts on BBT, so strong that I believe the name should probably be changed to BBH. As the five stages off the BBT were discribed above, these stages will now be addressed in the same order.

Cosmic Inflation issues

As more observations were made of what is called the CMB, questions began to arise since it was not exactly what BBT cosmologists expected. For example, "How could it be so smooth so early in the age (according to the BBT model) of the universe?" Temperature differences across the whole surface varied only by about 1 part in 10,000 compared to the interpreted mean temperature of ~2.7K. Guth was one of the most noted physicists to come up with a hypothesis to explain the cause of this "smoothing" and that is cosmic inflation. As discussed in more detail previously in this article, from the CMB data it was "backed out" that the space of the universe inflated at an incredible rate over a period of 10^{-32} of a second, expanding exponentially in size by a factor of 10^{26}. As mentioned earlier, Steinhardt and Ijjas [43], Monte Carlo computer simulation, showed that what we are seeing from the CMB could not be from inflation but by contraction. This hypothesis has led to a cyclic, or multi-verse cosmology.

Since we cannot observe (but only computer simulate) any thing that occurred prior to the surface of last scattering, i.e., the CMB, then neither inflation, nor contraction, is falsifiable, and therefore not true science.

Afterglow (or Ionic Recombination) issues

The CMB, or "afterglow" of the "big bang", along with Hubble's discoveries of galactic redshifts, are two of the main pillars supporting the BBT. The established acceptance of its interpretation as a cosmic (extragalactical) entity has spawned many other hypotheses that have attached themselves to the BBT, baryonic acoustic oscillations (BAOs), gravity waves, reference background for determining motion states, etc. However, the author, along with several other physiscists such as Robitailli [23, 24, 25, 26], Herouni [27], and Borissova [44], are not convinced it is extragalactical, but that it is a combination of earth atmospheric and nearby galactic sources. There is much observational evidence that supports this [45].

Dark Age issues

It appears that over a hundred mature galaxies have been observed either by the JWST [46] or the Atacama Large Millimeter/submillimeter Array (ALMA) [47,48]. Some of these are displayed in Figure 10. What is interesting is that these galaxies, according to the BBT, are estimated to only be 0.4 to 1.5 billion years old (at the time of their light emission), roughly one tenth of the BBT estimate of the age of the universe. This is highly inconsistent with what was predicted. Recall from Figure 8 that the earliest, i.e., least mature, galaxies were not expected to form until 1 billion years after the big bang.

Both JWST and ALMA have an advantage over telescopes limited to the visible range of light in that they include infrared and radio wavebands, allowing them to see through galactic dust. In [45] a hypothesis is advanced to explain what could be the root cause of such galactic maturity. Proponents of this hypothesis suggest that there could have been these galaxies appear to be massive because of their observed brightness. They suggest that this brightness could be due to several simultaneous star bursts. Such hypotheses, advanced in peer reviewed journals and technical papers, are typically accepted since they support the standard cosmological model. However, they are also typically unfalsifiable.

Large Structure Formation issues

As telescope technology has advanced, including the capacity to observe wavelengths greater than what is in the visible band, so has been the discovery of galaxies that are difficult to explain with the BBT model. Through spectroscopic techniques, we measure the rotation rates of matter within spiral galaxies at various distances from galaxy center. It has been confirmed that these rotation rates dramatically defy Newtonian physics in that they do not drop off with distance from the center of rotation. Such observations have led to the invention of CDM in the ΛCDM standard cosmology. CDM has never been directly observed but resides in complex computer simulations, controlled by many free parameters. Particle physicists have been called upon with the desire to detect a particle that would explain CDM but this has not happened yet.

However, this rotation rate versus radial distance has already been reconciled and accurately predicted with Modified Newtonian Dynamics, or MOND [49,50] without the need for dark matter. A former strong dark matter proponent, Stacy McGaugh, explored the MOND approach and performed independent tests on hundreds of spiral galaxies, using measured rotational velocities and generating plots showing the Tully-Fisher relation for each [51]. This research led him away from the dark matter assumption to a strong belief in MOND. A variant of MOND is MOG (Modified Gravity) that has been developed by John Moffat [52]. This model appears to have significant advantages over MOND due to its ability to accurately predict the behavior of wide binary systems.

A key principle associated with the BBT is that of the "cosmological principle", which states that all matter, on a large scale, is both homogeneous and isotropic. However, CDM does not do well at explaining or predicting observations on a small scale such as inner regions of galaxies where the model tends to predict more substructure than what is observed [53] . It is interesting to note that one of the reasons for assuming this cosmological principle is that it allows a straightforward application, or solution, of the Einstein's GR field equations. Without this simplification, his equations become so highly untennable and complex, requiring solutions to hundreds of equations and an accurate model of the mass distribution throughout the universe.

Finally, one last issue (although my list here is not exhaustive) associated with the failure of BBT predictions of large cosmological structures is that of recent JWST observations such as the "big ring" [54] and the "big arc" [55]. The big ring is a distinct circular, annulus-like, structure with a diameter of approximately 400 Mpc (or ~1.3 billion lightyears), which is a significant fraction of the universe. Lopez, at the University of Central Lancashire in Preston, England, along with her colleagues not only discovered the big ring but the big arc as well. This structure stretches out over 3 billion light years. These discoveries not only pose a serious challenge to the BBT large structure formation models and original estimated time of the big bang, but perhaps even more importantly, the assumption that the universe can be modeled as homogenous and isotropic, a major pillar of the BBT.

Accelerated Expansion issues

There are many issues with the BBT claim not only of expansion, but also accelerated expansion of the universe. Here I will only address a few. First of all, there is no directly observed causal mechanism that drives expansion of what is called De Sitter space. So one was invented. It is called "dark energy". Not only was this entity assumed but additionally the associated striking trait that it reproduces itself during the expansion so that its energy density remains constant. Such an assumption appears to violate energy conservation.

As mentioned earlier, there is a well accepted test among cosmologists that one can apply to astronomical observations to determine whether or not the universe is expanding. The Tolman, or surface brightness (SB), test and was applied by Eric Lerner in [21]. He performed, along with his colleagues, an in-depth analysis of astronomical data from both the Hubble Space Telescope (HST) and JWST [56]. In this work, they determined the SB for hundreds of galaxies of the same size and luminosity with various redshifts up to z = 5. Their findings strongly support the non-expanding universe model, with SB ratios in line with $SB \propto \frac{1}{z+1}$ rather than $\frac{1}{(z+1)^4}$. The former relationship is what one should expect for a non-expanding universe while the latter represents what is expected for an expanding universe.

Expansion of the universe, in general, is based predominantly on the interpretation of observed redshifts. However, as I addressed in [57], redshifts do not necessarily require motion. They can also be caused by inherent atomic structure, or energy levels, of a light-emitting object and are known as intrinsic redshifts. Arp and Narlikar demonstrated this in [15] in his quasar research. Over many years, Arp documented a host of observations where the quasar redshift and that of its nearby parent galaxy had sizable differences [60]. Critics of Arp, supporting the expanding universe model, claim the quasar is in a far more distant location. However, these critics could not account for the obvious detected bridge of observed matter between the quasar and its parent galaxy. They also could not explain the observed quantization of redshifts, where Arp's model does.

As stated in the previous section, with the observation of super large structures on the scale of the observable universe assumed by BBT, the Cosmological Principle no longer holds. If these new findings (i.e., big ring, big arc) are true, we can no longer claim universal homogeneity and isotropy of matter distribution. However, the foundational Friedmann equations for the BBT require this assumption.

One final BBT expansion issue I would like to address is that of Hubble tension. Over the past decade there has been a significant disagreement on the value that should be used for the instantaneous (current) Hubble constant, H_0. As was explained in [57], it is a prediction of the current rate of expansion for the universe. The value derived from the LCDM model is around 68 km/sec/Mpc and the value derived from observations of stars is roughly 73 km/sec/Mpc. The difference between these is well outside the measurement and analysis uncertainties. However, a team of physicists at the University of Chicago, led by Wendy Freedman recently reported that, using JWST observational data for selected stars, the uncertainty spread for H_0, bridges the gap between these two values [61]. It is too early to say this has been confirmed but probably will since it gives support to the ΛCDM model. Of course, galactic recessive motion was assumed to be the cause of the redshift in Freedman's work.

Conclusion

In this lengthy article I have laid out major points related to the BBT model in terms of its development history and its assumed evolutional growth stages. I also included serious criticisms of this model. In conclusion, I find that the BBT has failed multiple times in predicting observations such as the CMB, spiral galaxy rotation phenomena, and maturity of early galaxies. It also fails to pass the SB test which indicates a non-expanding universe. Furthermore, BBT proponents reject, without concrete explanations, such observations as Robitailli's indepth study of CMB measurement methods and results. The mainstream phyiscs establishment is so dependent on the CMB being cosmic that it must reject any denial, even though strong observational evidence declares it to be caused by infrared and microwave sources within our own galaxy [54]. They also have rejected Alton Arp's detailed observations that include quantized redshifts along with redshifts that could not fit the expanding model due to the many clear observations that two sources within the same galaxy are strongly different z values. Such failures beg the questions, "If the BBT is wrong, what should we do, continue to add more "epicycles"? Interpret the big bang to be the origin of but one cycle of a multiverse chain? Do we abandon the BBT and replace it with another cosmology ? If so, what cosmology should that be?". I believe this last two questions to be the proper ones to ask. However, more than likely, the multiverse option will survive as the most widely accepted answer if it has not already.

References

[1] R. Wells, "Issues with the Expanding Universe Model ", *General Science Journal*, Sep 2024.

[2] LAMBDA - ΛCDM Model of Cosmology (nasa.gov)

[3] V. Slipher, "The radial velocity of the Andromeda Nebula", Lowell Observatory Bulletin, vol. 2, no. 8, pp.56-57, 1913.

[4] Carl Wirtz (August 24, 1876 — February 18, 1939), German Astronomer, university professor | World Biographical Encyclopedia (prabook.com)

[5] D. Hogg, etal., "The K correction", https://arxiv.org/abs/astro-ph/0210394

[6] A. Einstein, "The Foundation of the General Theory of Relativity". *Annalen der Physik*. **354** (7):769. (1916). Bibcode:1916AnP...354..769E. doi:10.1002/andp.19163540702. Archived from the original (PDF) on 2012-02-06.

[7] A. Friedmann*, "Über die Krümmung des Raumes". Z. Phys. (in German).* ***10*** *(1): (1922) Bibcode:1922ZPhy...10..377F. doi:10.1007/BF01332580. S2CID 125190902.* (English translation: *Friedman, A (1999). "On the Curvature of Space". General Relativity and Gravitation.* ***31*** *(12): 1991–2000. Bibcode:1999GReGr..31.1991F. doi:10.1023/A:1026751225741. S2CID 122950995.*). The original Russian manuscript of this paper is preserved in the Ehrenfest archive.

[8] A. G. Lemaitre, A. S. Edington, "The Expanding Universe", *Monthly Notices of the Royal Astronomical Society*, Volume 91, Issue 5, Mar 1931.

[9] E. Hubble, M. Humason, "The velocity-distance relation among extra-galactic nebulae," Astrophysical Journal, vol. 74, pp. 43–80 (1931).

[10] F. Zwicky, "On the Red Shift of Spectral Lines through Interstellar Space", *Proceedings of the National Academy of Sciences*, **15** (10): 773–779, Oct 1929.

[11] G., Gamow, 'On the Origin of Galaxies', Properties of Matter under Unusual Conditions (Edward Teller 60th Birthday Volume). New York; John Wiley & Sons, Inc. Interscience Publishers. (1968)

[12] F. , Hoyle, "The Synthesis of the Elements from Hydrogen". *Monthly Notices of the Royal Astronomical Society*. **106** (5): 343–383. 1946.

[13] R. Dicke, P. J. Peebles, "Cosmic Black-body Radiation", *American Astronomical Society*,

Palmer Physical Laboratory Princeton, New Jersey, May 1965.
[14] R. Penrose, "Black Holes, Cosmology and Space-Time Singularities", University of Oxford Lecture.
[15] J. Narlikar, H. Arp, "Flat Spacetime Cosmology – A Unified Framework for Extra galactical Redshifts", *Astrophysical Journal*, 1993, 405, 51-56.
[16] R. Wells, "A Brief Assessment and Comparative Analysis of Major Gravity Models", *General Science Journal*, Jun 2024.
[17] D. Page, "Hawking Radiation and Black Hole Thermodynamics", https://arxiv.org/abs/hep-th/0409024
[18] S. W. Hawking et al., "A smooth exit from eternal inflation?", *Journal of High Energy Physics* (2018). [19] A. Guth**,** "Inflationary universe: A possible solution to the horizon and flatness problems". ***P****hysical Review D*. **23** (2): 1981.
[20] R. Wells, **"**Various Interpretations of the Cosmic Microwave Background," *General Science Journal*, Aug 2024.
[21] E. Lerner, "The Big Bang Never Happened", Crown, 1991 & Vintage, 1992.
[22] E. Lerner, "Galactic Model of Element Formation", *IEEE Transactions on Plasma Science*, VOL. 17, NO. 2, Apr 1989.
[23] P.M. Robitailli, "Water, Hydrogen Bonding, and the Microwave Background", *Progress in Physics*, Vol. 2, Apr 2009.
[24] P.M. Robitailli,"COBE: a Radiological Analysis", *Progress in Physics*, Vol. 4, Oct 2009.
[25] P.M. Robitailli, "WMAP: A Radiological Analysis", *Progress in Physics*, Vol. 1, Jan 2007.
[26] P.M. Robitailli, "The Planck Satellite LFI and the Microwave Background: Importance of the 4 K Reference Targets", *Progress in Physics*, Vol. 3, Jul 2010.
[27] P. Herouni, "Measured Parameters of Large Antenna of ROT-54/2.6 Tell about Absence of Big Bang", *Astrophysics*, Vol 1., 2007.
[28] W. Thornhill, D. Talbott, "The Electric Universe," Mikamar Publishing, May 2007.
[29] W. Thornhill, "The Electric Universe Illuminates Recent Discoveries," *Proceedings of the NPA*, Vol. 9, Albuquerque, NM 2012.
[30] W. Thornhill, "The Z-Pinch Morphology of Supernova 1987A and Electric Stars," *IEEE Transactions on Plasma Science*, Vol. 35, Issue 4, 2007.
[31] P. Steinhardt, A. Ijjas, "Bouncing Cosmology Made Simple," arXiv:1803.01961v1 [astro-ph.CO] 6 Mar 2018.
[32] D. Eisenstein, H. Wayne, "Baryonic Features in the Matter Transfer Function," https://ui.adsabs.harvard.edu/link_gateway/1998ApJ...496..605E/arxiv:astro-ph/9709112
[33] J. Miralda-Escuda, "The Dark Age of the Universe," *Science*, Vol. 300, Jun 2003, www.sciencemag.org,
[34] F. Hoyle, et.al., "Synthesis of the Elements in Stars," *Reviews of Modern Physics*. 29 (4): 547. 1957.
[35] J. Jeans, "Astronomy and Cosmogony", Cambridge University Press, 1929.

[36] R. Wells, "Rapid Star Formation Theory", *General Science Journal*, Feb 2024.

[37] K. Cooper, "Galaxy Shapes Explained by Collisions and Mergers," *Astronomy Now*, Jan 2010.

[38] J. de Swart, "Deciphering dark matter: the remarkable life of Fritz Zwicky," *Nature*, Sep 2019.

[39] A. Riess, "My Path to the Accelerating Universe", Nobel Lecture, Dec 2011.

[40] P. Milonni, et. al., "Casimir Physics", Springer, Lecture Notes in Physics 834, Jun 2011.

[41] J. Stoltenberg, D. Pengra, and R. Van Dyck, "Lamb Shift in Atomic Hydrogen," University of Washington, Physics Lecture 432, Apr 2023, link: lamb_shift.pdf

[42] T. Padmanabhan, "Cosmological constant—the weight of the vacuum," *ScienceDirect Physics Reports*, Vol 380, Issues 5-6, Jul 2003, link here.

[43] P. Steinhardt, A. Ijjas, "Bouncing Cosmology Made Simple," arXiv:1803.01961v1 [astro-ph.CO] 6 Mar 2018.

[44] L. Borissova, D. Rabounski, "On the Nature of the Microwave Background at the Lagrange 2 Point. Part II", *Progress in Physics*, Vol. 4, Oct 2007.

[45] R. Wells, "Various Interpretations of the Cosmic Microwave Background," *General Science Journal*, Aug 2024, pp. 2-14.

[46] K. Cooper, "The James Webb Space Telescope's early galaxy images were oddly bright. Now we know why," Space.com *News*, Oct 2023.

[47] I. Nijman, "Galaxies in the Infant Universe Were Surprisingly Mature," National Radio Astronomy Observatory (NARO), News Release: October 27, 2020.

[48] W. Clavin, "Rotating galaxies galore: New results from ALPINE reveal what appear to be spiral galaxies in the infant universe," *Nature Portfolio OA Journal*, Apr 2020.

[49] M. Milgrom, "The MOND Paradigm of Modified Dynamics", *Scholarpedia*, 9(6):31410, 2014.

[50] R. Scarpa, "Modified Newtonian Dynamics, an Introductory Review", arXiv:astro-ph/0601478, 2006.

[51] S. McGaugh, "MOND in the Early Universe", arXiv:astro-ph/9812328v1, 1998.

[52] J. Moffat, "Modified Gravity (MOG), Cosmology and Black Holes," arXiv:2006.12550 **[gr-qc]**

[53] D. Weinberg, et.al., "Cold dark matter: controversies on small scales," arXiv:1306.0913v1 [astro-ph.CO] 4 Jun 2013.

[54] A. Lopez, etal., "A Big Ring on the Sky," arXiv:2402.07591v2 [astro-ph.CO] 10 Jul 2024.

[55] L. Grossman, "An arc of galaxies 3 billion light-years long may challenge cosmology," *Science News*, Jun 2021.

[56] E. Lerner, R. Falomo, R. Scarpa, "UV surface brightness of galaxies from the local universe to z ~ 5", *International Journal of Modern Physics D*, Volume 23, Issue 6, id. 1450058, May 2014.

[57] R. Wells, "Far Galactic Redshift Analysis, Assuming Variable Speed of Light," *General Science Journal*, Dec 2023.

[58] H. Arp, " Catalogue of Discordant Redshift Associations", Published by C. Roy Keys Inc., Montreal, Quebec H2W 2B2 Canada