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An Overview of the Cosmological Big Bang Theory of the Universe

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Abstract

The most popular theory of our universe's origin centers on a cosmic cataclysm unmatched in all of history—the big bang. This theory was born of the observation that galaxies are moving away from each other with great speed, in all directions, as if they had all been propelled by an ancient explosive force. This paper therefore reviews the big bang theory and its observational evidences and concludes with the present understanding of the Big Bang.

Introduction

Our curiosity about the existence of our universe has led us to question about how did our universe begin? How old is our universe? How did matter come to exist? Our place in this universe? The place of the universe itself? Obviously, these are not simple questions but scientist have spent much time and effort looking for some clue (Chris and Blaire 1995). Through the understandings of modern science we have been able to provide firm theories for some of the answers we once called hypotheses but these answers lead to more intriguing and complex questions. One of the most persistently asked questions has been: How was the universe created? It was once believed that the universe had no beginning or end and was truly infinite. Through the Big Bang theory with its firm observational foundation, no longer could the universe be considered infinite. The universe was forced to take on the properties of a finite phenomenon, possessing a history and a beginning. (Chris and Blaire 1995)

In basic principle, about some billion years ago (~15) (Chris and Blaire 1995) the Big Bang occurred in a volume of space much less than the present size of the universe with high energy density, high pressure and temperature. What existed prior to this event is completely unknown and is a matter of pure speculation. This occurrence was not a conventional explosion but rather an event filling all of space with all of the energy of the embryonic universe rushing away from each other. The Big Bang actually consisted of an explosion of space within itself unlike an explosion of a bomb were fragments are thrown outward. (Chris and Blaire 1995). Just before the big bang, it is speculated that the entire vastness of the observable universe, including all of its matter, energy and radiation, was compressed into a hot, dense energy in a minute volume of space. This nearly incomprehensible state is theorized to have existed for just a fraction of the first second of time (Gannon 2012). Thus, an explosion some 15-20 billion years ago allowed all the universe's known matter (structures and all) and energy—even space and time themselves—to spring from some ancient and unknown type of energy (Gannon 2012). The theory maintains that, in the instant—a trillion-trillionth of a second—after the big bang, the universe expanded with incomprehensible speed from its pebble-size origin to astronomical scope. Expansion has apparently continued, but much more slowly, over the ensuing billions of years. (Gannon 2012). It is believed that as time passed and the universe cooled, more diverse kinds of atoms began to form which eventually condensed into the stars and galaxies of our present universe (Krauss 2012).

Georges Lemaitre first suggested the big bang theory in the 1920s when he theorized that the universe began from a single primordial atom. The idea subsequently received major boosts by Edwin Hubble's observations that galaxies are speeding away from us in all directions, and from the discovery of cosmic microwave radiation by Arno Penzias and Robert Wilson The glow of cosmic microwave background radiation, which is found throughout the universe, is thought to be a tangible remnant of leftover light from the big bang (Krauss 2012)

OBSERVATIONAL EVIDENCE OF THE BIG BANG THEORY

The observational evidence of the theory includes, cosmic inflation, cooling, cosmic acceleration, the expansion of the universe according to Hubble's law (as indicated by the redshifts of galaxies), discovery and measurement of the cosmic microwave background and the relative abundances of light elements produced by Big Bang nucleosynthesis, cosmological horizon, cosmic microwave background Radiation, Abundance of primordial elements, Galaxy formation and evolution and Structure formation, Primordial gas clouds, Dark Energy, Dark Mater, Magnetic monopole, the Horizon problems, the Flatness Problem (Gladders 2007):

COSMIC INFLATION AND BARYOGENESIS

The earliest phases of the Big Bang are subject to much speculation. In the most common models the universe was filled homogeneously and isotopically with a very high energy density and huge temperatures and pressures and was very rapidly expanding and cooling. Approximately 10−37 seconds into the expansion, a phase transition caused a cosmic inflation, during which the universe grew exponentially (Guth 1998). After inflation stopped, the universe consisted of a quark–gluon plasma, as well as all other elementary particles (Schewe 2005). Temperatures were so high that the random motions of particles were at relativistic speeds, and particle–antiparticle pairs of all kinds were being continuously created and destroyed in collisions. At some point an unknown reaction called baryogenesis violated the conservation of baryon number, leading to a very small excess of quarks and leptons over antiquarks and antileptons—of the order of one part in 30 million. This resulted in the predominance of matter over antimatter in the present. (Schewe 2005).

Cooling

The universe continued to decrease in density and fall in temperature, hence the typical energy of each Particle was decreasing. Symmetry breaking phase transitions put the fundamental forces of physics and the parameters of elementary particles into their present form (Kolb and Turner 1988)). After about 10−11 seconds, the picture becomes less speculative, since particle energies drop to values that can be attained in particle physics experiments. At about 10−6 seconds, quarks and gluons combined to form baryons such as protons and neutrons. The small excess of quarks over antiquarks led to a small excess of baryons over antibaryons. The temperature was now no longer high enough to create new proton–antiproton pairs (similarly for neutrons–antineutrons), so a mass annihilation immediately followed, leaving just one in

1010 of the original protons and neutrons, and none of their antiparticles. A similar process happened at about 1 second for electrons and positrons. After these annihilations, the remaining protons, neutrons and electrons were no longer moving relativistically and the energy density of the universe was dominated by photons (with a minor contribution from neutrinos).A few minutes into the expansion, when the temperature was about a billion kelvin and the density was about that of air, neutrons combined with protons to form the universe's deuterium and helium nuclei in a process called Big Bang nucleosynthesis (Kolb and Turner (1988). Most protons remained uncombined as hydrogen nuclei. As the universe cooled, the rest mass energy density of matter came to gravitationally dominate that of the photon radiation. After about 379,000 years the electrons and nuclei combined into atoms (mostly hydrogen); hence the radiation decoupled from matter and continued through space largely unimpeded. This relic radiation is known as the cosmic microwave background radiation (Peacock 1999). The chemistry of life may have begun shortly after the Big Bang, 13.8 billion years ago, during a habitable epoch when the universe was only 10–17 million years (Abraham 2014).

COSMIC ACCELERATION: (ACCELERATING UNIVERSE)

Independent lines of evidence from Type Ia supernovae and the CMB imply that the universe today is dominated by a mysterious form of energy known as dark energy, which apparently permeates all of space. The observations suggest 73% of the total energy density of today's universe is in this form. When the universe was very young, it was likely infused with dark energy, but with less space and everything closer together, gravity predominated, and it was slowly breaking the expansion. But eventually, after numerous billion years of expansion, the growing abundance of dark energy caused the expansion of the universe to slowly begin to accelerate. Dark energy in its simplest formulation takes the form of the cosmological constant term in Einstein's field equations of general relativity, but its composition and mechanism are unknown and, more generally, the details of its equation of state and relationship with the Standard Model of particle physics continue to be investigated both through observation and theoretically (Peebles and Ratra Bharat 2003).

METRIC EXPANSION OF SPACE

General relativity describes space-time by a metric, which determines the distances that separate nearby points. The points, which can be galaxies, stars, or other objects, `themselves, are specified using a coordinate chart or "grid" that is laid down over all space-time. The cosmological principle implies that the metric should be homogeneous and isotropic on large scales, which uniquely singles out the Friedmann–Lemaitre–Robertson–Walker metric (FLRW metric). This metric contains a scale factor, which describes how the size of the universe changes with time. This enables a convenient choice of a coordinate system to be made, called commoving coordinates. In this coordinate system the grid expands along with the universe, and objects that are moving only because of the expansion of the universe remain at fixed points on the grid. While their coordinate distance (commoving) remains constant, the physical distance between two such commoving points expands proportionally with the scale factor of the universe (d'Inverno, 1992).

The Big Bang is not an explosion of matter moving outward to fill an empty universe. Instead, space itself expands with time everywhere and increases the physical distance between two commoving points. In other words, the Big Bang is not an explosion in space, but rather an expansion of space. Because the FLRW metric assumes a uniform distribution of mass and energy, it applies to our universe only on large scales—local concentrations of matter such as our galaxy are gravitationally bound and as such do not experience the large-scale expansion of space (Tamara M. Davis and Charles H retrieved Dec 2016).

COSMOLOGICAL HORIZON

An important feature of the Big Bang space-time is the presence of horizons. Since the universe has a finite age, and light travels at a finite speed, there may be events in the past whose light has not had time to reach us. This places a limit or a past horizon on the most distant objects that can be observed. Conversely, because space is expanding, and more distant objects are receding ever more quickly, light emitted by us today may never "catch up" to very distant objects. Our understanding of the universe back to very early times suggests that there is a past horizon, though in practice our view is also limited by the opacity of the universe at early times. So our view cannot extend further backward in time, though the horizon recedes in space. If the expansion of the universe continues to accelerate, there is a future horizon as well. (Croswell, 1995)

HUBBLE'S LAW AND THE EXPANSION OF SPACE

Observations of distant galaxies and quasars show that these objects are redshifted—the light emitted from them has been shifted to longer wavelengths. These redshifts are uniformly isotropic, distributed evenly among the observed objects in all directions. If the redshift is interpreted as a Doppler shift, the recessional velocity of the object can be calculated. For some galaxies, it is possible to estimate distances via the cosmic distance ladder. When the recessional velocities are plotted against these distances, a linear relationship known as Hubble's law is observed (Hubble, 1929). At present, the Hubble's constant is measured to be $70.4^{+1.3}_{-1.4}$ km/s/Mpc by the WMAP probe (Jarosik, 2011). Hubble's law has two possible explanations. Either we are at the center of an explosion of galaxies—which is untenable given the Copernican principle—or the universe is uniformly expanding everywhere. This universal expansion was predicted from general relativity by Alexander Friedman (1922) and Georges Lemaitre (1927) well before Hubble made his 1929 analysis and observations (Peacock 1999). Measurements of the effects of the cosmic microwave background radiation on the dynamics of distant astrophysical systems in 2000 proved the Copernican principle that, on a cosmological scale, the Earth is not in a central position. (Srianand, et.al. 2000). Radiation from the Big Bang was demonstrably warmer at earlier times throughout the universe. Uniform cooling of the cosmic microwave background over billions of years is explainable only if the universe is experiencing a metric expansion, and excludes the possibility that we are near the unique center of an explosion (Srianand, et.al. 2000)

COSMIC MICROWAVE BACKGROUND RADIATION:

In 1965 Arno Penzias and Robert Wilson serendipitously discovered the cosmic background radiation, an omnidirectional signal in the microwave band (Penzias and Wilson, 1965). Their discovery provided substantial confirmation of the big-bang predictions by Alpher, Herman and Gamow around 1950. Through the 1970s the radiation was found to be approximately consistent with a black body spectrum in all directions; this spectrum has been redshifted by the expansion of the universe, and today corresponds to approximately 2.725 K.

The surface of last scattering corresponding to emission of the CMB occurs shortly after recombination, the epoch when neutral hydrogen becomes stable. Prior to this, the universe comprised a hot dense photon-baryon plasma sea where photons were quickly scattered from free charged particles. Peaking at around 372±14 $*10^{\wedge 3}$ year (Spergel, 2003), the mean free path for a photon becomes long enough to reach the present day and the universe becomes transparent. In 1990, COBE satellite made which made high-precision spectrum measurements of CMB frequency spectrum and indicates that it is almost a perfect blackbody with no deviations at a level of 1 part in 104, and measured a residual temperature of 2.726 K. In 1992, further COBE measurements discovered tiny fluctuations (anisotropies) in the CMB temperature across the sky, at a level of about one part in 10^5 (Boggess, 1992). During the following decade, CMB anisotropies were further investigated by a large number of ground-based and balloon experiments. In 2000–2001 several experiments, most notably BOOMERANG, found the shape of the universe to be spatially almost flat by measuring the typical angular size (the size on the sky) of the anisotropies (Melchiorri 1999; de Bernardis 2000; Miller 1999).

In early 2003 the first results of the WMAP were released, yielding what were at the time the most accurate values for some of the cosmological parameters. The results disproved several specific cosmic inflation models, but are consistent with the inflation theory in general. (Spergel, 2006) The Planck space probe was launched in May 2009. Other ground and balloon based cosmic microwave background experiments are ongoing.

ABUNDANCE OF PRIMORDIAL ELEMENTS

Using the Big Bang model it is possible to calculate the concentration of helium-4, helium-3, deuterium, and lithium-7 in the universe as ratios to the amount of ordinary hydrogen (Kolb and Turner 1988). The relative abundances depend on a single parameter, the ratio of photons to baryons. This value can be calculated independently from the detailed structure of CMB fluctuations. The ratios predicted (by mass, not by number) are about 0.25 for 4He/H, about 10−3 for 2H/H, about 10−4 for 3He/H and about 10−9 for 7Li/H (Kolb and Turner 1988). The measured abundances all agree at least roughly with those predicted from a single value of the baryon-to-photon ratio. The agreement is excellent for deuterium, close but formally discrepant for 4He, and off by a factor of two for 7Li with substantial systematic uncertainties. Nonetheless, the general consistency with abundances predicted by Big Bang nucleosynthesis is strong evidence for the Big Bang, as the theory is the only known explanation for the relative abundances of light elements, and it is virtually impossible to "tune" the Big Bang to produce much more or less than 20–30% helium (Barbara 2003; Steigman, 2005

GALAXY FORMATION AND EVOLUTION AND STRUCTURE FORMATION

Detailed observations of the morphology and distribution of galaxies and quasars are in agreement with the current state of the Big Bang theory. A combination of observations and theory suggest that the first quasars and galaxies formed about a billion years after the Big Bang, and since then larger structures have been forming, such as galaxy clusters and super clusters. Populations of stars have been aging and evolving, so that distant galaxies (which are observed as they were in the early universe) appear very different from nearby galaxies. Moreover, galaxies that formed relatively recently appear markedly different from galaxies formed at similar distances but shortly after the Big Bang. These observations are strong arguments against the steady-state model (Bertschinger, 1998, 2001).

PRIMORDIAL GAS CLOUDS

In 2011 astronomers found what they believe to be pristine clouds of primordial gas, by analyzing absorption lines in the spectra of distant quasars. Before this discovery, all other astronomical objects have been observed to contain heavy elements that are formed in stars. These two clouds of gas contain no elements heavier than hydrogen and deuterium (Fumagalli, et.al 2011). Since the clouds of gas have no heavy elements, they likely formed in the first few minutes after the Big Bang, during Big Bang nucleosynthesis.

VARIOUS VIEWS ABOUT THE BIG BANG

The Big Bang theory is the prevailing cosmological model that give a theoretical explanation to some of the observations in the universe from the earliest known periods through its subsequent large-scale evolution (Silk 2009; Singh 2005; Wollack 2010). The model accounts for the fact that the universe expanded from a very high density, high pressure and high temperature state and offers a comprehensive explanation for a broad range of phenomena, including the abundance of light elements, the Cosmic Microwave Background Radiation (CMBR), large scale structure and Hubble's law (Wright 2009). If the known laws of physics are extrapolated beyond where they have been verified, there is a singularity. Some estimates place this moment at to about 13.8 billion years ago, which is thus considered the age of the universe (Planck 2013). After the initial expansion, the universe cooled sufficiently to allow the formation of subatomic particles and later simple atoms. Giant clouds of these primordial elements later coalesced through gravity to form stars and galaxies (Planck 2013).

Though the scientific community was once divided between supporters of two different expanding universe theories, the Big Bang and the Steady State theory, accumulated empirical evidence provides strong support for the Big Bang (Kragh 1996). In 1929, from analysis of galactic redshifts, Edwin Hubble concluded that galaxies are drifting apart (Hubble 1929), this important observational evidence is consistent with the hypothesis of an expanding universe. In 1965 the CMBR was discovered, this is a crucial evidence in favor of the Big Bang model. More recently, measurements of the redshifts of supernovae indicate that the expansion of the universe is accelerating, an observation attributed to dark energy's existence (Peebles and Ratra 2003; Chow 2008). The Big Bang theory offers a comprehensive explanation for a broad range of observed phenomena, including the abundance of light elements, the cosmic microwave background (CMB), large scale structure, and Hubble's Law (Wright, E. 2009).The framework for the Big Bang model relies on Albert Einstein's theory of general relativity and on simplifying assumptions such as homogeneity and isotropy of space (the universality of physical laws and the cosmological principle). The governing equations were formulated by Alexander Friedman (Kragh 1996; Wright 2009). The cosmological principle has been confirmed to a level of 10−5 via observations of the CMB. The universe has been measured to be homogeneous on the largest scales at the 10% level. (Goodman, J. 1995)

Large particle accelerators can replicate the conditions that prevailed after the early moments of the universe, resulting in confirmation and refinement of the details of the Big Bang model. However, these accelerators can only probe so far into some high energy regimes. Consequently, the state of the universe in the earliest instants of the Big Bang expansion is still poorly understood and an area of open investigation and speculation (Chow 2008).

The first sub atomic particles to be formed included protons, neutrons, and `electrons. Though simple atomic nuclei formed within the first three minutes after the Big Bang, thousands of years passed before the first electrically neutral atoms formed (Chow 2008). The majority of atoms produced by the Big Bang were hydrogen, along with helium and traces of lithium. Giant clouds of these primordial elements later coalesced through gravity to form stars and galaxies, and the heavier elements were synthesized either within stars or during supernovae (Clavin 2014; Overbye 2014).

In 1912 Vesto Slipher measured the first Doppler shift of a spiral nebula and soon discovered that almost all such nebulae were receding from Earth (Slipher 1913). Ten years later, Alexander Friedmann, a Russian cosmologist and mathematician, derived the Friedmann equations from Albert Einstein's equations of general relativity, showing that the universe might be expanding in contrast to the static universe model advocated by Einstein at that time. (Friedman 1922). In 1924 Edwin Hubble's measurement of the great distance to the nearest spiral nebulae showed that these systems were indeed other galaxies. Independently deriving Friedman’s equations in 1927, Georges Lemaitre, proposed that the inferred recession of the nebulae was due to the expansion of the universe (Lemaitre 1927). Lemaitre in 1931 went further and suggested that the evident expansion of the universe, if projected back in time, meant that the further in the past the smaller the universe was, until at some finite time in the past all the mass of the universe was concentrated into a single point, a "primeval atom" where and when the fabric of time and space came into existence. (Lemaitre 1931; Christianson 1995; Peebles and Ratra 2003).

In the 1920s and 1930s almost every major cosmologist preferred an eternal steady state universe. Arthur Edington agreed with Aristotle that the universe did not have a beginning in time, viz., that matter is eternal. A beginning in time was "repugnant" to him. (Edington 1931; Appolloni, 2011). During the

1930s other ideas were proposed as non-standard cosmologies to explain Hubble's observations, including the Milne model, (Milne 1935); The oscillatory universe (originally suggested by Friedmann, but advocated by Albert Einstein and Richard Tolman, (Tolman 1934); the tired light hypothesis (Zwicky 1929); Hoyle's steady state model, whereby new matter would be created as the universe seemed to expand. In this model the universe is roughly the same at any point in time (Hoyle 1948).

The Lemaitre's Big Bang theory, advocated and developed by George Gamow, who introduced big bang nucleosynthesis (Alpher et al. 1948) and whose associates, Ralph Alpher and Robert Herman predicted CMBR (Alpher & Herman 1948). The discovery and confirmation of the CMBR in 1965 secured the Big Bang as the best theory of the origin and evolution of the universe. (Penzias & Wilson 1965). The current work in cosmology includes understanding how galaxies form in the context of the Big Bang, understanding the physics of the universe at earlier times and reconciling observations with the basic theory. In 1968 and 1970 Roger Penrose, Stephen Hawking and George F. R. Ellis published papers where they showed that mathematical singularities were an inevitable initial condition of general relativistic models of the Big Bang. (Hawking & Ellis 1968; Hawking & Penrose, 1970) Then, from the 1970s to the 1990s, cosmologists worked on characterizing the features of the Big Bang universe and resolving outstanding problems. In 1981 Alan Guth made a breakthrough in theoretical work on resolving certain outstanding theoretical problems in the Big Bang theory with the introduction of an epoch of rapid expansion in the early universe he called "inflation" (Guth 1981). Meanwhile, during these decades, two questions in observational cosmology generated much discussion and disagreement were over the precise values of the Hubble Constant (Huchra 2008) and the matter-density of the universe before the discovery of dark energy, thought to be the key predictor for the eventual fate of the universe, (Livio 2001). In the mid-1990s observations of certain globular clusters appeared to indicate that they were about 15 billion years old, which conflicted with most then-current estimates of the age of the universe (and indeed with the age measured today). This issue was later resolved when new computer simulations, which included the effects of mass loss due to stellar winds, indicated a much younger age for globular clusters (Navabi & Riazi 2003). Significant progress in Big Bang cosmology have been made since the late 1990s as a result of advances in telescope technology as well as the analysis of data from satellites such as COBE (Cosmic Background Explorer) (Boggess 1992) the Hubble Space Telescope and WMAP (Spergel 2006). Cosmologists now have fairly precise and accurate measurements of many of the parameters of the Big Bang model, and have made the unexpected discovery that the expansion of the universe appears to be accelerating.

UNRESOLVED ISSUES OF THE BIG BANG THEORY

Problems have arisen as a result of the Big Bang theory. Some of These problems have been resolved while others are still outstanding. Proposed solutions to some of the problems in the Big Bang model have revealed new mysteries of their own. For example, the horizon problem, the magnetic monopole problem, and the flatness problem are most commonly resolved with inflationary theory, but the details of the inflationary universe are still left unresolved and many, including some founders of the theory, say it has been disproven What follows are a list of the mysterious aspects of the Big Bang theory still under intense investigation by cosmologists and astrophysicists.

DARK ENERGY

Measurements of the redshift–magnitude relation for type Ia supernovae indicate that the expansion of the universe has been accelerating since the universe was about half its present age. To explain this acceleration, general relativity requires that much of the energy in the universe consists of a component with large negative pressure, dubbed "dark energy" (Peebles, and Ratra, 2003). Dark energy, though speculative, solves numerous problems. Measurements of the cosmic microwave background indicate that the universe is very nearly spatially flat, and therefore according to general relativity the universe must have almost exactly the critical density of mass/energy. But the mass density of the universe can be measured from its gravitational clustering, and is found to have only about 30% of the critical density (Peebles and Ratra, 2003). Since theory suggests that dark energy does not cluster in the usual way it is the best explanation for the "missing" energy density. Dark energy also helps to explain two geometrical measures of the overall curvature of the universe, one using the frequency of gravitational lenses, and the other using the characteristic pattern of the large-scale structure as a cosmic ruler.

Negative pressure is believed to be a property of vacuum energy, but the exact nature and existence of dark energy remains one of the great mysteries of the Big Bang. Results from the WMAP team in 2008 are in accordance with a universe that consists of 73% dark energy, 23% dark matter, 4.6% regular matter and less than 1% neutrino (Jarosik, 2011). According to theory, the energy density in matter decreases with the expansion of the universe, but the dark energy density remains constant (or nearly so) as the universe expands. Therefore, matter made up a larger fraction of the total energy of the universe in the past than it does today, but its fractional contribution will fall in the far future as dark energy becomes even more dominant (Rugh and Zinkernagel, 2002).

DARK MATTER

The dark energy component of the universe has been explained by theorists using a variety of competing theories including Einstein's cosmological constant but also extending to more exotic forms of quintessence or other modified gravity schemes. (Mortonson, et. al 2013). A cosmological constant problem sometimes called the "most embarrassing problem in physics" results from the apparent discrepancy between the measured energy density of dark energy and the one naively predicted from Planck units. During the 1970s and 1980s, various observations showed that there is not sufficient visible matter in the universe to account for the apparent strength of gravitational forces within and between galaxies. This led to the idea that up to 90% of the matter in the universe is dark matter that does not emit light or interact with normal baryonic matter. In addition, the assumption that the universe is mostly normal matter led to predictions that was strongly inconsistent with observations. In particular, the universe today is far lumpier and contains far less deuterium than can be accounted for without dark matter. While dark matter has always been controversial, it is inferred by various observations: the anisotropies in the CMB, galaxy cluster velocity dispersions, large-scale structure distributions, gravitational lensing studies, and X-ray measurements of galaxy clusters (Keel, 2009).

Indirect evidence for dark matter comes from its gravitational influence on other matter, as no dark matter particles have been observed in laboratories. Many particle physics candidates for dark matter have been proposed, and several projects to detect them directly are underway (Yao, 2006). Additionally, there are outstanding problems associated with the currently favored cold dark matter model which include the dwarf galaxy problem (Diemand, et. al 2005). Alternative theories have been proposed that do not require a large amount of undetected matter but instead modify the laws of gravity established by Newton and Einstein, but no alternative theory has been as successful as the cold dark matter proposal in explaining all extant observations (Dodelson, 2011).

HORIZON PROBLEM

The horizon problem results from the premise that information cannot travel faster than light. In a universe of finite age this sets a limit- the particle horizon on- the separation of any two regions of space that are in causal contact (Kolb and Turner 1988). The observed isotropy of the CMB is problematic in this regard: if the universe had been dominated by radiation or matter at all times up to the epoch of last scattering, the particle horizon at that time would correspond to about 2 degrees on the sky. There would then be no mechanism to cause wider regions to have the same temperature (Barbara 2003). A resolution to this apparent inconsistency is offered by inflationary theory in which a homogeneous and isotropic scalar energy field dominates the universe at some very early period (before baryogenesis). During inflation, the universe undergoes exponential expansion, and the particle horizon expands much more rapidly than previously assumed, so that regions presently on opposite sides of the observable universe are well inside each other's particle horizon. The observed isotropy of the CMB then follows from the fact that this larger region was in causal contact before the beginning of inflation (Guth, 1998).

Heisenberg's uncertainty principle predicts that during the inflationary phase there would be quantum thermal fluctuations, which would be magnified to cosmic scale. These fluctuations serve as the seeds of all current structure in the universe (Barbara 2003). Inflation predicts that the primordial fluctuations are nearly scale invariant and Gaussian, which has been accurately confirmed by measurements of the CMB (Spergel 2007). If inflation occurred, exponential expansion would push large regions of space well beyond our observable horizon (Guth, 1998).

MAGNETIC MONOPOLES

The magnetic monopole objection was raised in the late 1970s. Grand unified theories predicted topological defects in space that would manifest as magnetic monopoles. These objects would be produced efficiently in the hot early universe, resulting in a density much higher than is consistent with observations, given that no monopoles have been found. This problem is also resolved by cosmic inflation, which removes all point defects from the observable universe, in the same way that it drives the geometry to flatness (Kolb and Turner 1988),

FLATNESS PROBLEM

The overall geometry of the universe is determined by whether the Omega cosmological parameter is less than, equal to or greater than 1 (Kolb and Turner 1988). The flatness problem (also known as the oldness problem) is an observational problem associated with a Friedmann–Lemaitre–Robertson–Walker metric. The universe may have positive, negative, or zero spatial curvature depending on its total energy density. Curvature is negative if its density is less than the critical density, positive if greater, and zero at the critical density, in which case space is said to be flat. The problem is that any small departure from the critical density grows with time, and yet the universe today remains very close to flat, given that a natural timescale for departure from flatness might be the Planck time, 10−43 seconds (Overbye, 2014).

SPECULATIONS IN COSMOGONY

While the Big Bang model is well established in cosmology, it is likely to be refined. The Big Bang theory, built upon the equations of classical general relativity, indicates a singularity at the origin of cosmic time; this infinite energy density is regarded as impossible in physics. Still, it is known that the equations are not applicable before the time when the universe cooled down to the Planck temperature, and this conclusion depends on various assumptions, of which some could never be experimentally verified. One proposed refinement to avoid this would-be singularity is to develop a correct treatment of quantum gravity. (Hawking and Ellis, 1973). It is not known what could have preceded the hot dense state of the early universe or how and why it originated, though speculation abounds in the field of cosmogony. Some proposals, each of which entails untested hypotheses, are:

- Models including the Hartle–Hawking no-boundary condition, in which the whole of space-time is finite; the Big Bang does represent the limit of time but without any singularity (Hartle and Hawking, 1983).
- Big Bang lattice model, states that the universe at the moment of the Big Bang consists of an infinite lattice of fermions, which is smeared over the fundamental domain so it has rotational, translational and gauge symmetry. The symmetry is the largest symmetry possible and hence the lowest entropy of any state (Bird, 2011).
- Brane cosmology models, in which inflation is due to the movement of branes in string theory; the pre-Big Bang model; the ekpyrotic model, in which the Big Bang is the result of a collision between branes; and the cyclic model, a variant of the ekpyrotic model in which collisions occur periodically. In the latter model the Big Bang was preceded by a Big Crunch and the universe cycles from one process to the other (Langlois, 2002; Linde, 2002; Kennedy, 2007)
- Eternal inflation, in which universal inflation ends locally here and there in a random fashion, each end-point leading to a bubble universe, expanding from its own big bang. (Linde, 1986).

Proposals in the last two categories, sees the Big Bang as an event in either a much larger and older universe or in a multiverse.

RELIGIOUS INTERPRETATIONS OF THE BIG BANG THEORY

As a description of the origin of the universe, the Big Bang has significant bearing on religion and philosophy. (Harris, J. F. 2002 and Frame, T. 2009) .As a result, it has become one of the liveliest areas in the discourse between science and religion. (Harrison, P. 2010), some believe the Big Bang implies a creator. (Craig, William Lane 1999). And some see its mention in their holy books (Asad, Muhammad 1984) while others argue that Big Bang cosmology makes the notion of a creator superfluous.(Frame, T. 2009 and Sagan, C. 1988).

CONCLUSION

In summary, an attempt have been made at explaining the answers that science has revealed about our universe. Our understanding of the Big Bang is obviously incomplete. As time wears on, more discoveries are made, leading to infinite questions which require yet more answers. Unsatisfied with our base of knowledge research is being conducted around the world at this very moment to further our minimal understanding of the unimaginably complex universe.

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