Zero Kelvin Big Bang, an Alternative Paradigm:

III. The Big Bang

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Abstract

In the first paper of this series, we described a "cosmic fabric" which served as the birthplace of our universe: spin-oriented hydrogen atoms at zero kelvin in a matrix perhaps infinite and (almost) eternal. In the second paper we described how a portion of the cosmic fabric ultimately condensed into a Bose-Einstein condensate (BEC), Lemaître's "primeval atom". In this third paper we describe the Big Bang itself, an implosion-explosion event involving nuclear fusion of hydrogen into the primordial mix of elements. Using the ZKBB model, one can calculate the approximate temperature of the Big Bang as 5.7 billion K. The explosion fragmented the remaining BEC, propelling billions of fragments of "cosmic shrapnel" out from the locus of the Big Bang which ultimately evolved into the structures of our present universe.

Keywords: Zero Kelvin Big Bang, Bose-Einstein Condensate, Primeval Atom, Cosmic Shrapnel, Bosenova

1. Introduction

In the first two papers of this series we described how, by logic and extrapolation, one could hypothesize a transition from a cosmos in its initial ground state, the "cosmic fabric", to a structure of highly concentrated matter, immediately preceding the Big Bang. In this third paper we will describe the ZKBB explosive event itself. Instead of a Standard Big Bang (SBB) universe, springing from an infinitely dense and infinitely hot "singularity" by way of a quantum fluctuation, we propose a Zero Kelvin Big Bang (ZKBB) universe where it is a Bose-Einstein condensate (BEC) which undergoes an implosion – explosion. A nuclear fusion reaction produces the primordial mix of hydrogen, helium, and lithium, and simultaneously propels billions of pieces of the BEC as "cosmic shrapnel" out into space. In the ZKBB model, there was an actual Big Bang inflationary explosion. Our universe did have a beginning, it was the product of conventional physics, and it does have a center and a finite boundary.

After this third paper, detailing a Big Bang within the ZKBB paradigm, later papers will go on to describe some of the physical consequences which one can predict based on this paradigm, and show how these physical results are consistent with contemporary observations. We will also see how the ZKBB model obviates the "problems" associated with SBB theory (horizon problem, flatness problem, coincidence problem), and provides logical and obvious answers to many questions in modern cosmology, some supposedly answered by the SBB paradigm, and others still outstanding:

Why is spacetime "flat"; why is omega precisely and exactly 1.0000?

What is dark matter; is it really "missing"?

Why is the expansion of the universe accelerating; what is dark energy?

How did galaxies form; why do spiral galaxies have flat rotation curves?

The paper is organized as follows. Section 2 shows the sequential steps of the ZKBB model. Section 3 relates Lemaître's primeval atom to a BEC, and describes its unusual physical properties. Sections 4 and 5 cover a possible initiating event and propose a mechanism for an explosive Big Bang. Sections 6 and 7 point out the remarkable stoichiometry between the calculated Big Bang energy and that of the cosmic microwave background (CMB). Section 8 describes some of the observational consequences of the ZKBB model and section 9 provides a summary.

2. The ZKBB Model

First of all, we lay out a concise description of the total ZKBB model, complete with figures, illustrating each step in the process. This will facilitate a clearer conceptualization of the ZKBB sequence of events.

Figure 1 illustrates the structure of the cosmic fabric, a sparse distribution of singlet state "a", "down-up" (electron, proton) hydrogen atoms (see Figure 4, paper I), at zero K, perhaps infinite in extent and almost eternal.

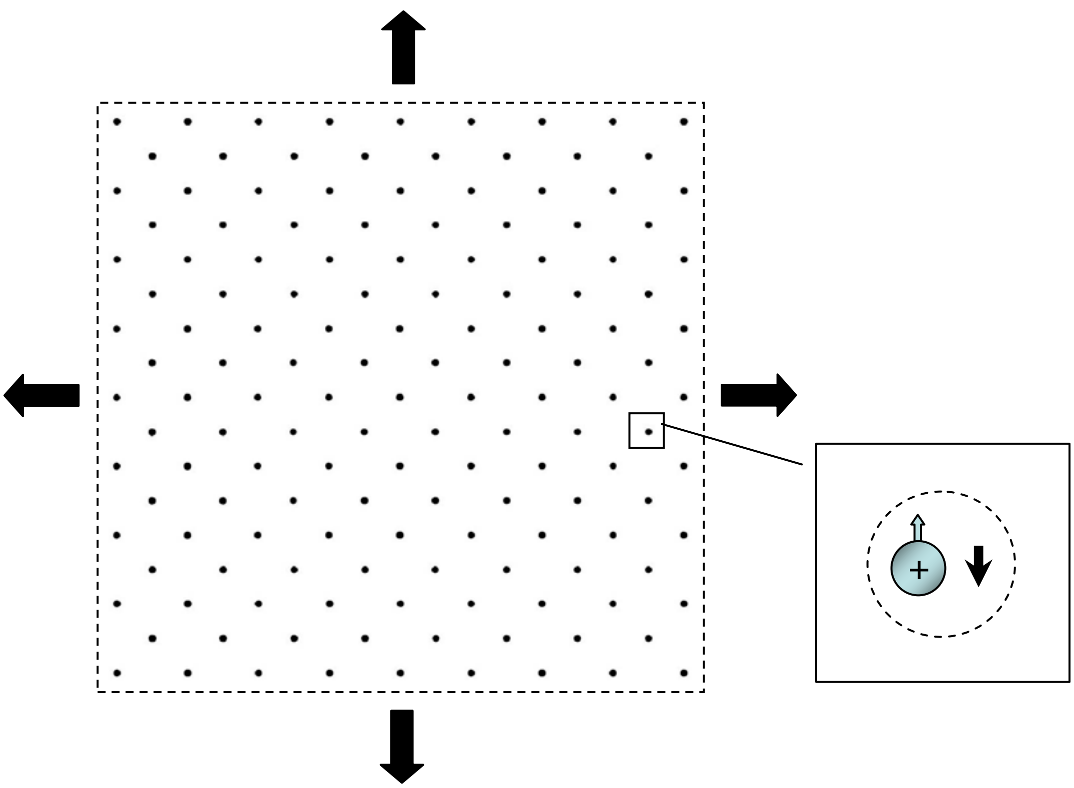

Figure 1: The Cosmic Fabric. An infinite (indicated by arrows) and (almost) eternally stable matrix of singlet state hydrogen atoms at the lowest possible energy state (proton and electron anti-parallel, shown in box to the right), mutually repulsive, and at equilibrium at zero kelvin. Black dots represent "a" state atomic hydrogen (see box to the right of diagram, details in Paper I of this series). Hydrogen atoms are at a density of, at most, a few atoms per cubic meter of space. This cosmic fabric is proposed as the pre-existing state of the cosmos before the Big Bang.

Figure 2 illustrates the condensation of a region of the cosmic fabric into a Bose-Einstein condensate (BEC) at the center of a structure of very dense matter that eventually contains essentially all of the mass of the future universe. The accumulation of hydrogen atoms into the condensate concurrently creates a spherical “matter-depletion zone” surrounding the growing BEC.

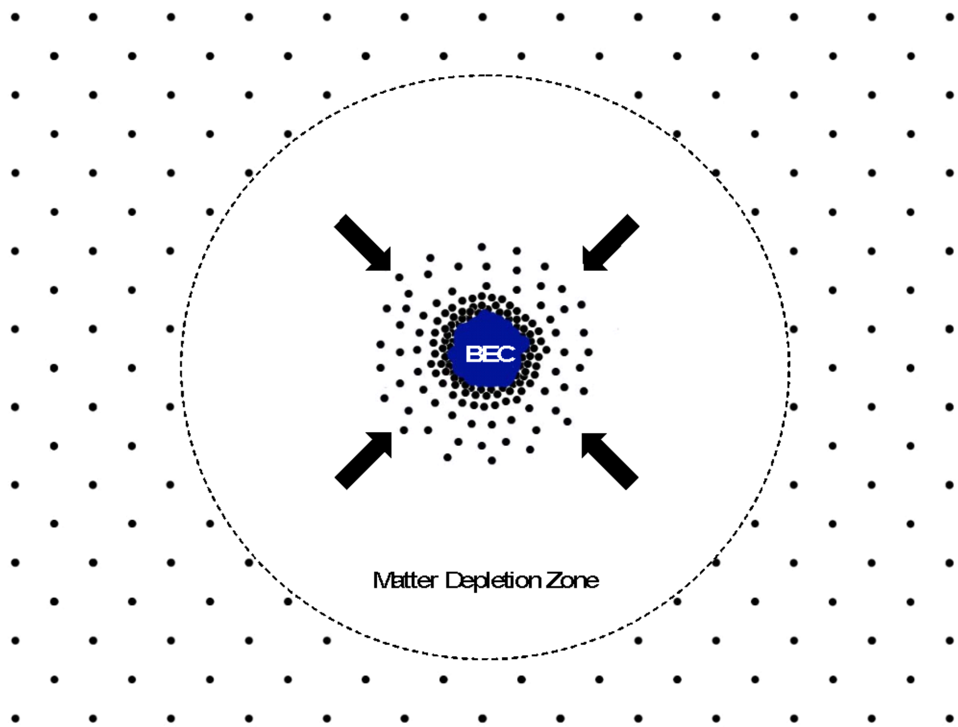

Figure 2. Bose-Einstein Condensation of Singlet State Atomic Hydrogen into a Primeval Atom. Formation of a gravitational dimple at a single point in the cosmic fabric initiates formation of a Bose-Einstein condensate (BEC – shown in blue). As BEC formation is a self-reinforcing process, hydrogen atoms from the surrounding cosmic fabric would be drawn towards and into the BEC (indicated by arrows), creating a spherical matter-depletion zone between the primeval atom (BEC) and the surrounding cosmic fabric.

This mass accumulation continues until a catastrophic cascade of events occurs, characterized by formation of molecular hydrogen, and causing the primeval atom to suddenly implode. This initial step of the Big Bang event is shown in Fig. 3.

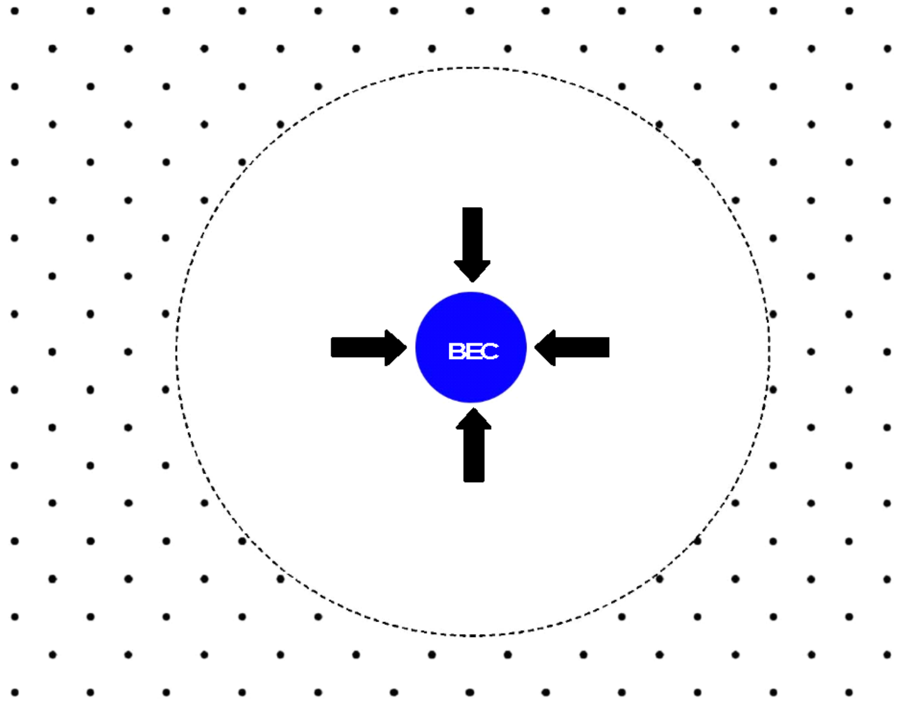

Figure 3: Implosion of the Primeval Atom. Formation of molecular hydrogen causes the Bose-Einstein condensate (BEC) at the center of the matter depletion zone to suddenly implode. The BEC undergoes heating and compression.

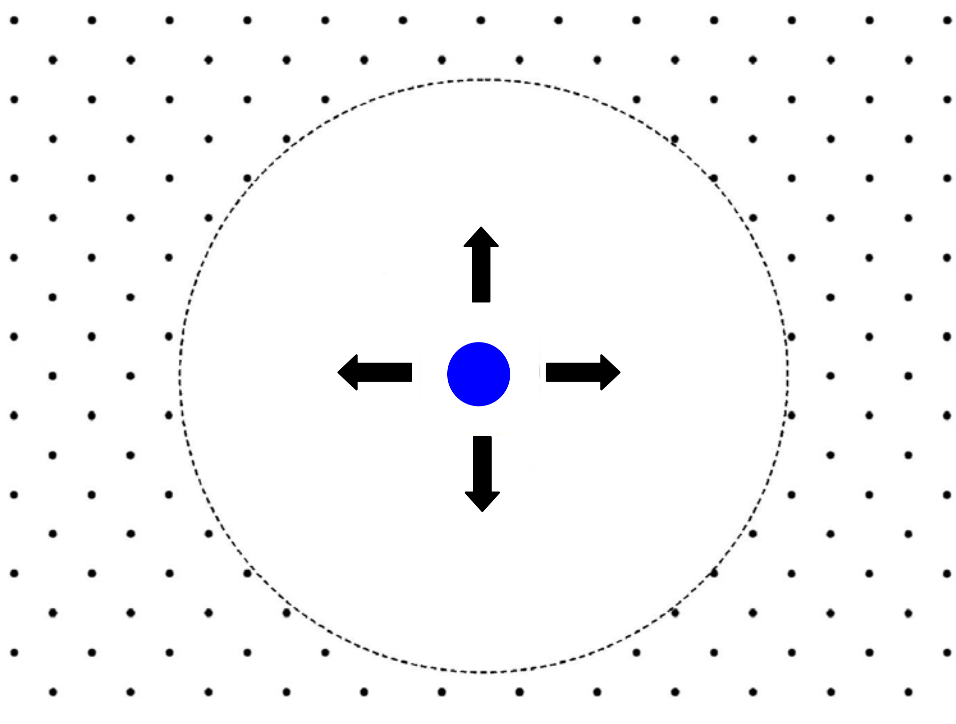

Figure 4: The Big Bang. The primeval atom explodes due to nuclear fusion reactions, producing primordial element abundance.

The implosion, Fig. 3, initiates nuclear fusion, whereby atomic hydrogen in a portion of the primeval atom is converted into helium and small amounts of lithium. The sudden energy release is an actual inflationary Big Bang explosion as depicted in Fig. 4.

Figure 5 illustrates the physical consequences of this implosion-explosion Big Bang. The parts of the BEC which did not undergo nuclear fusion are fragmented, and the fragments are ejected in a spherical distribution around the locus of the Big Bang. After billions of years this pattern, modified by further fragmentation, dispersion, sublimation, and interaction among the fragments, has created the matter distribution which we now observe as our universe.

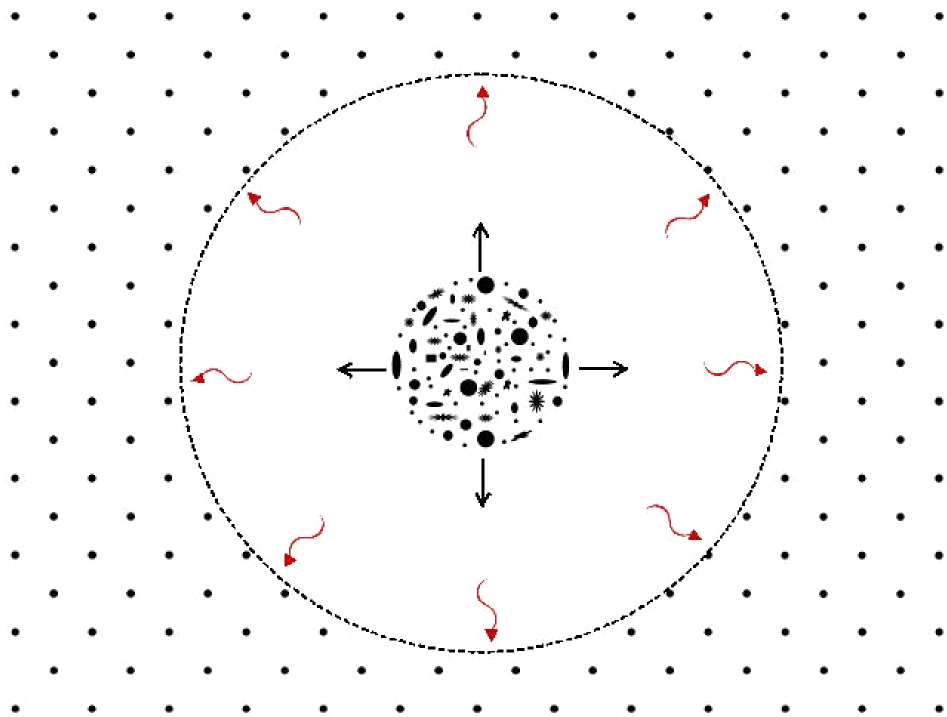

Figure 5: Expansion of the Universe. Remnants of the BEC are propelled into the matter-depletion zone as "cosmic shrapnel" as the universe expands (straight arrows). Energy produced by the Big Bang (wavy red arrows) radiates out across the matter-depletion zone until it interacts with the surrounding cosmic fabric.

Also shown in Fig. 5, the electromagnetic energy generated in the Big Bang travels for billions of years out across the matter-depletion zone, until finally encountering the primal cosmic fabric "wall" beyond.

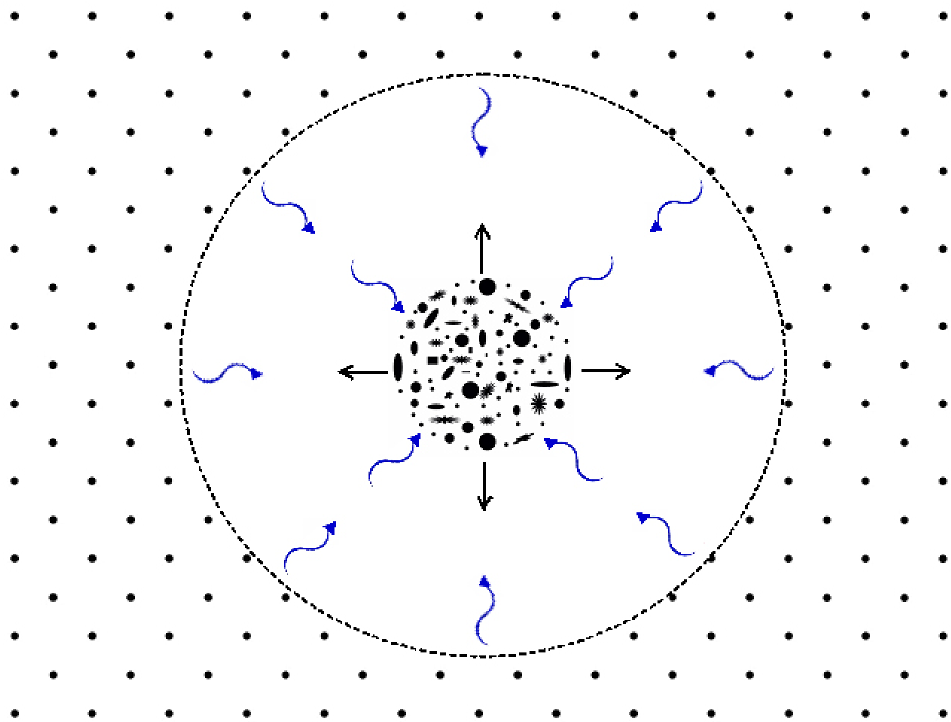

Figure 6: The Cosmic Microwave Background (CMB). When the energy from the Big Bang encounters the surrounding cosmic fabric, the cosmic fabric acts as a perfect black body, absorbing 100% of the energy and re-emitting radiation (wavy blue arrows) back toward the locus of the explosion. This radiation impacts the still-expanding universe as the cosmic microwave background (CMB).

As shown in Fig. 6, the peripheral cosmic fabric, which is still at zero K, acts as a **perfect** blackbody; it absorbs all of the energy and re-emits approximately half back to the universe, as the cosmic microwave background (CMB) radiation. In this model, the CMB can legitimately be considered a true "echo" of the Big Bang, not only as a picturesque figure of speech, but also as a physical reality.

The soliton gravity waves generated by the Big Bang, also traveling at the speed of light, would rebound from the cosmic fabric "wall" back towards the expanding universe. The pattern created in the matter distribution of the universe as these waves bounce off opposite sides of the universe and may have given rise to the periodicity of structure and the baryonic acoustic oscillations (BAO) which have been observed. These and other consequences of the Zero Kelvin Big Bang will be addressed in more detail in future papers

3. The "Primeval Atom" as Bose-Einstein Condensate

In the previous paper (Paper II), the primeval atom is hypothesized as a Bose-Einstein condensate (BEC) of singlet state, spin-oriented atomic hydrogen. It is remarkable that Georges Lemaître actually conceptualized the primeval atom as a single quantum in 1931 (Lemaître, 1931). This was a result of his belief that the universe had evolved by a process similar to radioactive decay, which was a popular field of study at that time. If there was a primeval atom, and it was a BEC, then Lemaître's conjecture of a single quantum would be vindicated. With a universe beginning as a quantum object, perhaps the ZKBB paradigm provides a physical manifestation of the elusive link between quantum theory and relativity at the beginning of the universe, a connection for which physicists have been searching for decades.

Certain properties of BECs are quite interesting, and will be significant when one considers the observational consequences of a Zero Kelvin Big Bang. First of all, the BEC is not the uniform, monolithic object that one might envision. The central portion of mass would be a uniform condensed state, but the periphery would be a region of highly concentrated individual atoms, continuously entering and exiting the BEC; it is a structure in dynamic equilibrium.

As a prelude to future papers, we could mention here some of the unusual properties of BECs, properties which may have determined how the universe evolved and dictated future observational reality. One property is super-conductivity; an electric current initiated in it will perpetuate forever, with no decrease in energy. If rotating, a super-conductor can create a permanent magnetic field around itself. Another property is that of a super-fluid, with zero viscosity, and therefore no energy loss as it moves. A rotating BEC also does not behave as a monolithic entity, but behaves as a collection of quantum vortices. It is most likely a combination of these unusual properties which ultimately determine what the universe looks like, many billions of years later. The physical cosmological consequences of these unusual properties will be covered in later papers.

4. Initiation of the Big Bang

As described above, the BEC/primeval atom was in an essentially equilibrium condition, with hydrogen atoms transitioning between the BEC and the surrounding space, and a slow trickle of hydrogen atoms still being dragged in from the periphery of the matter-depletion zone. Figure 2 depicts the aggregation of hydrogen atoms into the BEC, creating a huge matter-depletion zone where the mass density approached zero. At zero kelvin, with no energy, one could easily imagine this condition continuing indefinitely, but it did not. There was a Big Bang, otherwise we would not be here to try to decipher how it might have happened. What might have occurred to upset this delicate balance, and precipitate such a monumental event? The following scenario describes how it could have happened, based on conventional physics.

The initiating event may have been as simple as a "spin-flip" of the electron on one of the hydrogen atoms in the cloud surrounding the BEC. In the relatively high density environment, this could result in the formation of a molecule of hydrogen (Fig. 7, Fig. 8). The energy required to effect a spin-flip of atomic hydrogen is only 5.9×10^{-6} eV, equivalent to 0.07K. But at zero kelvin, there is no energy, and therefore the chance of a spin-flip occurring is once in never. However this is where quantum theory may intervene, because in quantum theory there is never a "never"; if something consistent with the laws of physics can happen, eventually it will. An electron spin-flip occurring in one atom out of more than 10^{80} atoms (the estimated number of atoms in the universe), over the course of eternity, may have been such an event.

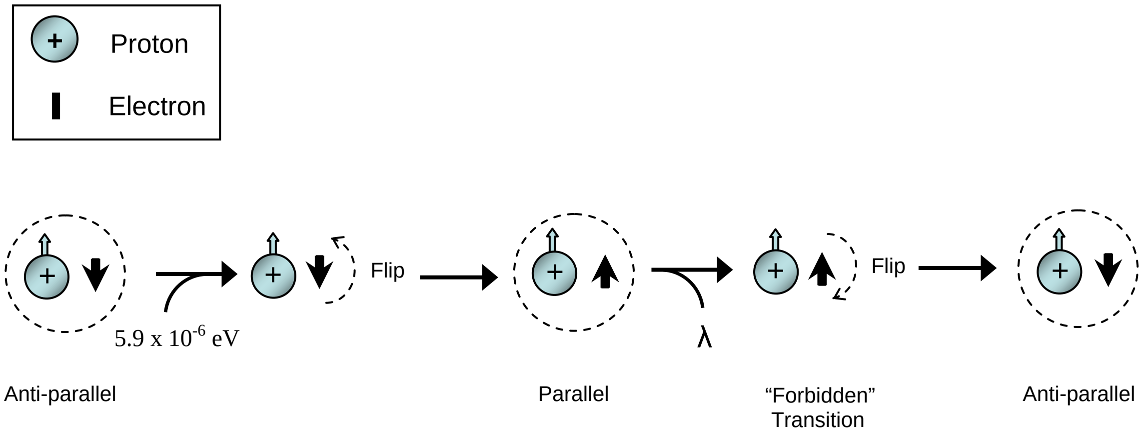

Figure 7: The Mechanism of a Spin-flip of Atomic Hydrogen. A spin-flip of hydrogen may have initiated the Big Bang. Only atoms with opposite electron spins (spin up and spin down, indicated by arrows) can form molecular hydrogen. A spin-flipped hydrogen returning to its original state is a "forbidden" transition with a half-life of approximately 10 million years.

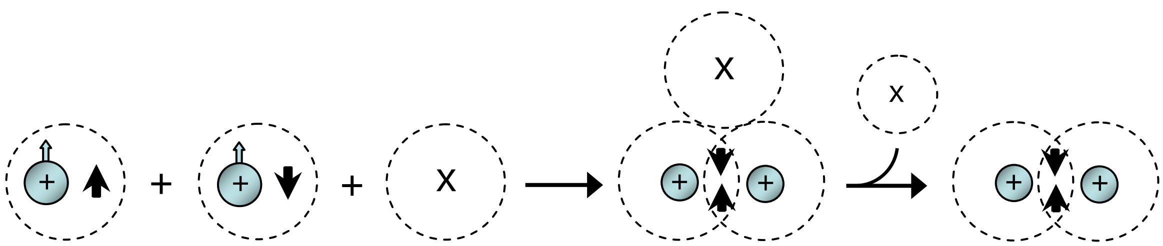

Figure 8: The Three-body Reaction which Produces Molecular Hydrogen. Note that the reacting hydrogen atoms have electrons with opposite spins.

At the mass density of the original cosmic fabric, or even billions of times higher, such a spin-flip would be of little consequence. The half-life of the spin-flipped state is about 10 million years before the electron would revert to its original lower energy level. It takes this long because the reverse flip involves a "forbidden" transition; but even a forbidden transition eventually occurs given enough time (Fig. 7). Even though a hydrogen atom with a flipped electron would now be free to react with one having the opposite electron spin, at a low matter density the chance of two atoms contacting each other during this interval is essentially nil.

However, in the very high mass-density environment around the BEC, the situation is completely different. Here, with hydrogen atoms packed closely together, there is a good chance that the flipped atom would encounter another hydrogen atom with opposite spin, before it flipped back to its initial state. But it is not that simple. Unfortunately, another hurdle has to be overcome before the two atoms can react to form a molecule of hydrogen, H_2, because the reaction is actually a “three body process” (Fig. 8). According to the Law of Conservation of Angular Momentum, the angular momentum of particles participating in any chemical reaction must be conserved. It turns out that the angular momentum of the hydrogen molecule is less than the combined angular momentum of the two original hydrogen atoms. This excess momentum has to be transferred to another body for the reaction to proceed; in this case it is to a third atom, and thus a three-body reaction. So it is easy to see why the odds of a universe-initiating event are so low; it is like once in never to the third power. However, in the high density environment surrounding a BEC, it did happen at least once, resulting in our universe.

5. The Big Bang

As suggested above, the initiating event for the Big Bang may have been as simple as a single electron spin-flip on one hydrogen atom. How could this simple, and highly unlikely event, trigger a thermonuclear Big Bang explosion, and is there any actual evidence that this mechanism might be correct? The quick answer is yes.

If a spin-flip occurred and a three-body reaction actually took place, what would be the consequences? The reaction of two hydrogen atoms forming a hydrogen molecule releases a large amount of energy, 4.5 eV, equivalent to about 55,100K. In the concentrated environment around the BEC, before this energy dissipated it could initiate a multitude of spin-flips on nearby atoms. This could start a kind of chain reaction, where each molecule formation reaction precipitates even more spin-flips, which results in further molecule formation, etc. etc. This reaction might then rapidly propagate around the entire shell of atomic hydrogen gas surrounding the BEC, where conditions were conducive to this process. Even though hot molecular hydrogen gas might be expected to expand in space, since it now had energy, the gravitational effect of the BEC would tend to restrain an immediate expansion. And since a hydrogen molecule inherently occupies less space than the combined space of the two individual hydrogen atoms, one could envision an actual contraction in space. The rapid conversion of a substantial mass of atomic hydrogen to molecular hydrogen in the shell around the BEC could result in a sudden contraction of space around the BEC, in other words, an **implosion**.

John A. Wheeler, in his memoir *Geons, Black Holes & Quantum Foam* (1998) describes one of the breakthroughs in the development of the hydrogen bomb. Stan Ulam was first to propose a concept that was then expanded by Edward Teller, in which the key to creating a self-sustaining nuclear fusion reaction was not in maintaining a high temperature, as had been supposed. Instead, the key was to substantially reduce the volume of space in which the reaction occurred. The required compression was ultimately supplied by a nuclear fission reaction, an atom bomb. Thus, the terrestrial explosion of a thermonuclear fusion device (hydrogen bomb) is facilitated by an initial implosion; so this sequence of events we are suggesting for a zero kelvin Big Bang is not a foreign concept by any means. In and around the BEC, this combination of gravitational restraint, space contraction, and huge energy release due to molecule formation, may have been sufficient to initiate nuclear fusion, starting with the production of neutrons.

As described earlier, a BEC has many atoms all occupying the same phase space, so this close proximity of hydrogen atoms in a high density BEC might be expected to facilitate nuclear fusion. An implosion would force protons and electrons together to form neutrons, neutrons would be captured by hydrogen atoms to form deuterium and tritium, and deuterium would react to form helium. The result of this nuclear fusion process would be the sudden release of an immense surge of energy. If only part of the BEC participated in the reaction, the remainder would be fragmented by the blast, and the fragments propelled out into space with a wide range of mass, velocity and rotation. In ZKBB theory, it is the properties of the residual fragments of BEC which determine how the fragments eventually evolve into the structures in our observable universe.

6. Temperature

One obvious question is: if not a temperature of infinity or even the Planck temperature, then how hot was the Big Bang? Here, using the ZKBB model and basic logic, we estimate it to be about 6 billion K. We start with matter at zero kelvin, and consider it as a closed system. If one converts a fraction of the mass into energy via nuclear fusion, and applies that energy to the remaining mass, how hot would this remaining mass become? Since this involves a fractional calculation and not an absolute mass calculation, it does not matter how much mass we start with.

Starting with 1 mole of atomic hydrogen, 1.00782 g

Cosmologists estimate the primordial element mix after the Big Bang to be about 75% hydrogen and 25% helium. So the amount of hydrogen remaining would be 1.0078 g/mole x 0.75 moles = 0.75587 g

In the nuclear fusion of hydrogen to helium, the mass loss is 0.7 % x (0.25 x 1.0078) = 0.00179 g

The net remaining mass is 1.00782 – 0.00179 = 1.00603 g

This would include 0.25016 g / 4.0026 (helium atomic weight) = 0.0625 moles of helium

Total moles: 0.75 (hydrogen) + 0.0625 (helium) = 0.8125 moles of matter

With $E = mc^2$, the mass loss is equivalent to (0.907 x 10^{14} joules/g) x (0.00179 g) = 1.63 x 10^{11} joules of energy

This energy released and applied to the residual mass would be (1.63 x 10^{11} J) / (0.8125 moles) = 2.0024 x 10^{11} J/mole

With a heat capacity of this mixture of hydrogen/helium assumed to be about 34.9 joules per mole per kelvin at constant volume (assumed with gravitational constraint), the temperature of the remaining mass would be (2.0024 x 10^{11} J/mole) / (34.9 J/mole/K) = 5,737,530,000 K, or about **5.7 billion kelvin** if all of the energy was released as thermal energy. Admittedly this is hot, but not infinitely hot, or even close to the trillion K temperature sometimes mentioned in the SBB model.

7. The Evidence

It turns out that this 5.7 billion kelvin temperature is in remarkable agreement with a completely independent measurement of energy in the universe, namely that of the cosmic microwave background radiation (CMB), if one ventures to use the ZKBB model as the operational paradigm. Perhaps one of the greatest missed opportunities in cosmology came in 1998, in a paper by Burbidge and Hoyle (1998). From the early data on the cosmic microwave background (CMB), they observed that the total CMB energy was close to what one would expect from the nuclear fusion of 25% of a primordial hydrogen universe into helium. If one subscribed to a generic explosive Big Bang universe, this would immediately and obviously suggest that the Big Bang could have been an instantaneous, explosive fusion reaction, similar to that hypothesized by ZKBB. Unfortunately, the authors were operating within the paradigm of the steady-state universe model and used this result to suggest that the energy came from the cumulative release of energy from multiple generations of trillions of stars over trillions of years in a steady state universe. So rather than applying Occam’s razor, and selecting what would appear to be the most obvious process which fit the observations, the data was instead interpreted as support for the steady-state universe model.

What is the evidence that the implosion-explosion process described for the ZKBB might actually have been the Big Bang mechanism? The most compelling evidence comes from experiments conducted by a research team at NIST and the University of Colorado (Roberts et al. 2001; Donley et al. 2001, 2002), and later confirmed and extended by others. While studying a BEC of rubidium-85, they manipulated the magnetic field surrounding the BEC (via Feshbach resonance), changing the interaction between atoms from repulsive to attractive. At first the BEC contracted as expected. But then it suddenly collapsed and **exploded**, leaving behind a small remnant of the BEC. Approximately half of the atoms had also disappeared from the apparatus. This may have been because they could no longer be visualized with the detection system being used, but no definite solution to this aspect of the experiment has been forthcoming. In keeping with the musical genre of the time, and with physicists rarely at a loss for imaginative names, this event was creatively named a “bosenova”.

It was hypothesized that the reason for this bosenova may have been the sudden creation of molecules from the rubidium atoms. Just as hypothesized for the ZKBB process, this would have resulted in the contraction of space, creating an implosive burst of energy, and a rebound explosion. Scaling up this process from 10^4 atoms to 10^{80} atoms is a significant conceptual leap. However the fact that a BEC has actually been shown to implode-explode, most likely due to molecule formation, indicates that a similar mechanism for the beginning of the universe cannot be arbitrarily ruled out.

8. Observational Consequences of ZKBB

There are certain consequences which one might expect as the result of the ZKBB sequence of events. We will briefly touch on the major ones here, while deferring more detailed analyses to future papers.

8.1 Cosmic Microwave Background (CMB) Radiation

With the cosmic fabric "shell" surrounding the matter-depletion zone as the "surface of last scattering", equidistant from the original radiation source (the Big Bang), there would be no "horizon problem". The CMB would be observed as being almost exactly isotropic, which it is.

With the cosmic fabric shell originally at zero kelvin, it would also act as a **perfect** black-body, and the re-emitted radiation would have an almost perfect black-body spectrum, which it does.

8.2 The "Flatness Problem" - Omega Equal to One

If one considered the past-eternal cosmic fabric as having the critical density, then omega (ratio of universe density to critical density) would be approaching one, as our universe expanded to refill its original volume. It would be exactly and precisely 1.00000… when it reaches that new equilibrium point.

8.3 Dark Matter

It is predictable that essentially all of the expected dark matter will eventually be found as various forms of hydrogen. Astronomers and cosmologists have already suggested molecular hydrogen as gas (Pfenniger et al. 1993; Pfenniger & Combes, 1993; Heithausen, 2004) and in clumps (Combes & Pfenniger, 1998; Lin et al. 2011). Other scientists have speculated about black holes containing the missing matter (Frampton et al. 2010; Kesden & Hanasoge, 2011; Hawkins, 2011). ZKBB would agree with the latter assessment, but here the black holes would be BECs of hydrogen, and would be black because they are cold, and not because they are holes.

8.4 Lambda or Dark Energy

The pressure differential between the mass/energy of our universe, and the almost complete vacuum of the matter-depletion zone, would manifest itself as a negative pressure or "vacuum energy"; this is exactly what is observed. Since it is always in reference to "the vacuum", lambda has always been proportional to, and will always be proportional to, this mass/energy. It is not a cosmological constant because it is not constant; it was higher in the past when the mass/energy density was higher, and will continue to decrease as the universe continues to expand.

8.5 Flat Galactic Rotation Curves

Galaxies are not gravitationally stable structures at equilibrium, with motions which follow Newtonian-Keplerian dynamics. The observed flat galactic rotation curves are a reflection of the processes which formed the galaxies (fragmentation, dispersion, interaction, and sublimation of Bose-Einstein condensates). This is in contrast to the accretion-aggregation of gas clouds mechanism proposed by SBB, requiring very finely-tuned, and exquisitely placed dark matter halos around each galaxy, none of which have been observed.

8. Summary

Using conventional physics with minimal supernatural assumptions, we have laid out a logical trail of matter and mechanisms consistent with a Zero Kelvin Big Bang universe. In subsequent papers we will turn our attention to the physical consequence of this Big Bang, what one might expect to see, and how this compares to actual astronomical observations. We will see how issues which are perceived as problems for conventional SBB theory, are obvious and natural consequences of the ZKBB model, and strong evidence in support of it. These issues include dark matter, dark energy, a flat universe with omega equal to one, and the flat rotation curves of spiral galaxies.

Acknowledgements

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