Zero Kelvin Big Bang, an Alternative Paradigm:

III. The Big Bang

Royce Haynes
Lewes, Delaware, USA
royce.haynes@comcast.net

Abstract

In the first paper in 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), the "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 we see in our present universe.

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

Introduction

In the first two papers in 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, lithium and beryllium, and simultaneously propels billions of pieces of the BEC ("cosmic shrapnel") out into space. One piece of this shrapnel would eventually disperse, producing the Milky Way, the solar system, and Earth. In the ZKBB model, the universe did have a "beginning", it was the product of conventional physics and, contrary to the SBB model, it does have a center and an "edge" (at least a very diffuse one).

After this third paper, detailing a Big Bang within the ZKBB paradigm, later papers will describe some of the physical consequences which one can predict, and show how the 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 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?
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 ZKBB Model

First of all, let us lay out a concise description of the total ZKBB model, complete with figures, illustrating each step in the process. This will make it easier for the reader to then conceptualize the ZKBB mechanism itself. Figure 1 illustrates the structure of the cosmic fabric, a sparse distribution of singlet state “a”, “down-up” hydrogen atoms (see Figure 4 from Zero Kelvin Big Bang, an Alternative Paradigm: I. Logic and the Cosmic Fabric), at zero K, perhaps infinite in extent and almost eternal.

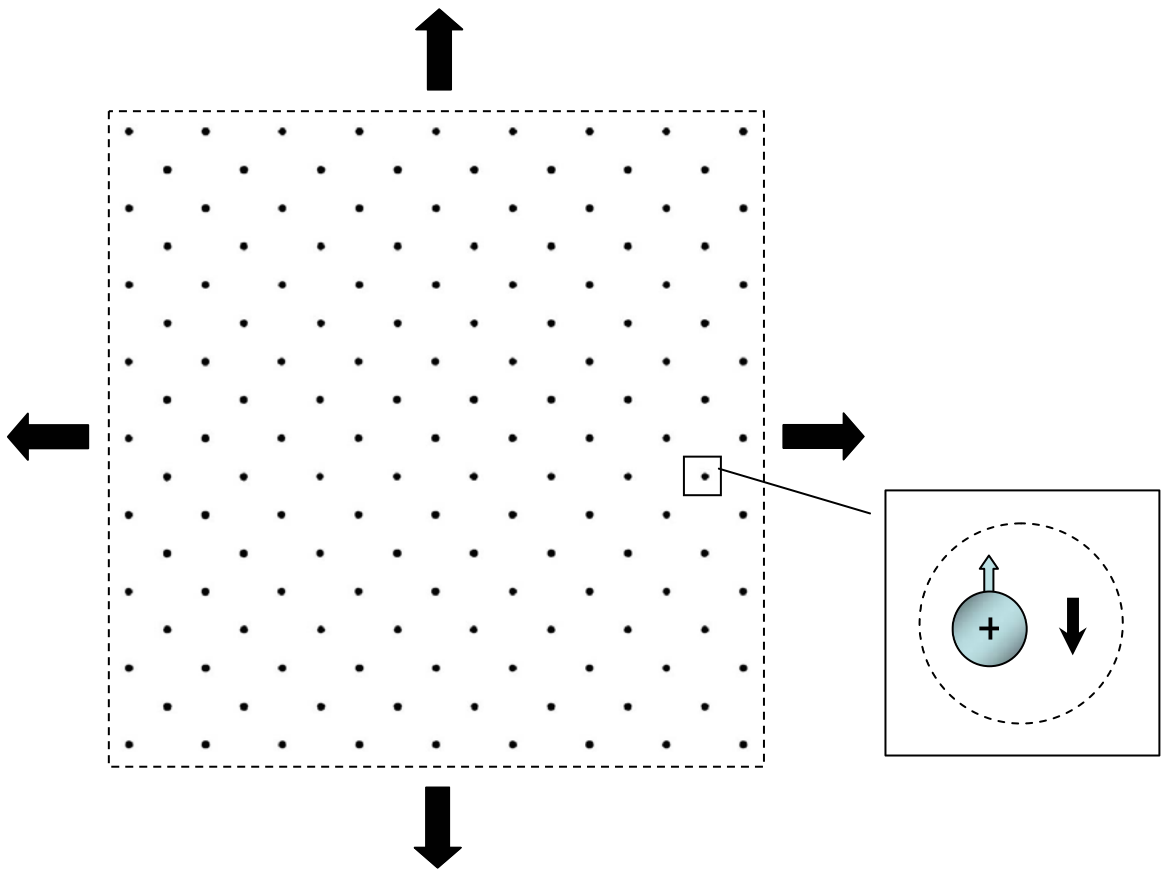

Figure 1: Cosmic fabric of spin-oriented hydrogen atoms (black dots).

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

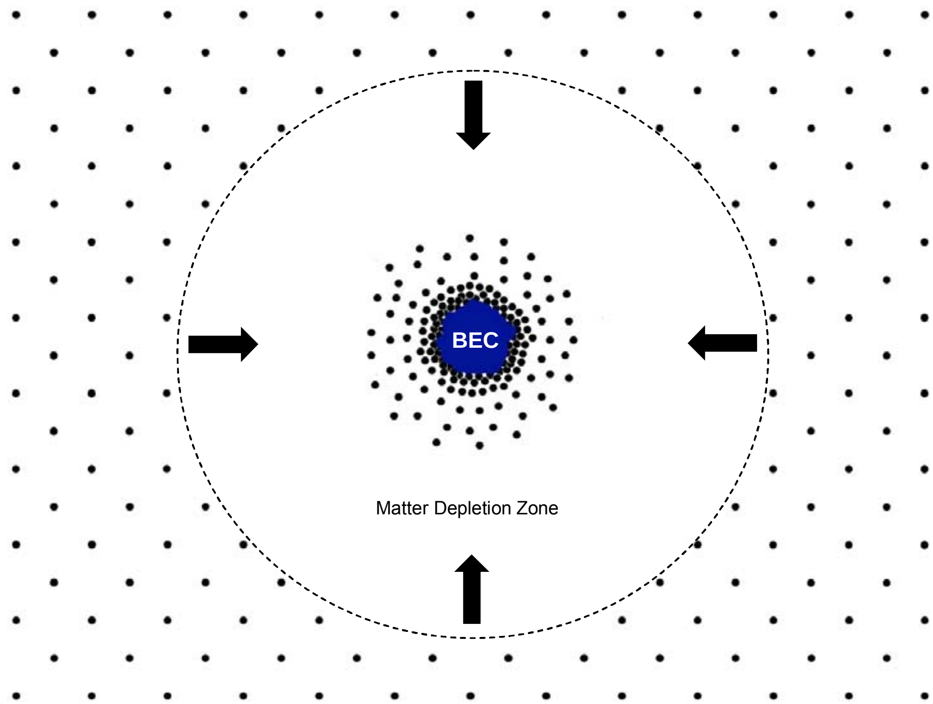

Figure 2: Formation of a Bose-Einstein condensate (BEC) of atomic hydrogen draws in surrounding atoms and creates the "primeval atom" (blue). A "matter depletion zone" is formed in the surrounding space due to BEC formation.

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

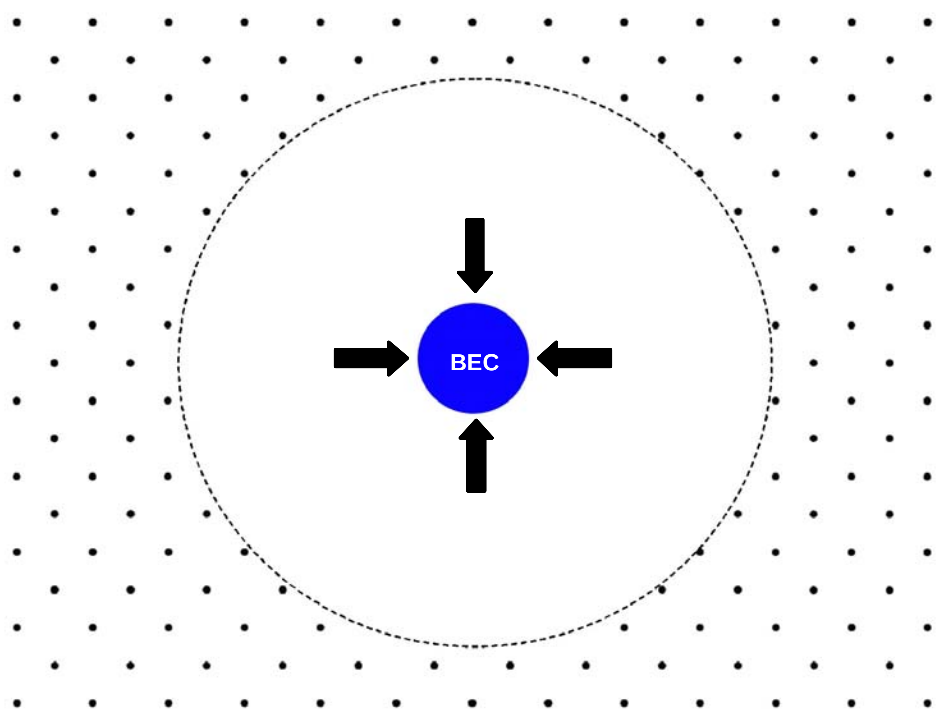

Figure 3: Primeval atom implodes due to formation of molecular hydrogen. The BEC undergoes heating and compression.

The implosion shown in figure 3 creates conditions conducive to nuclear fusion, whereby atomic hydrogen in some of the primeval atom is converted into the primordial mix of elements; about 75% hydrogen, 25% helium and miniscule amounts of lithium and beryllium. The sudden release of such a tremendous burst of energy is an actual Big Bang explosion as depicted in Figure 4.

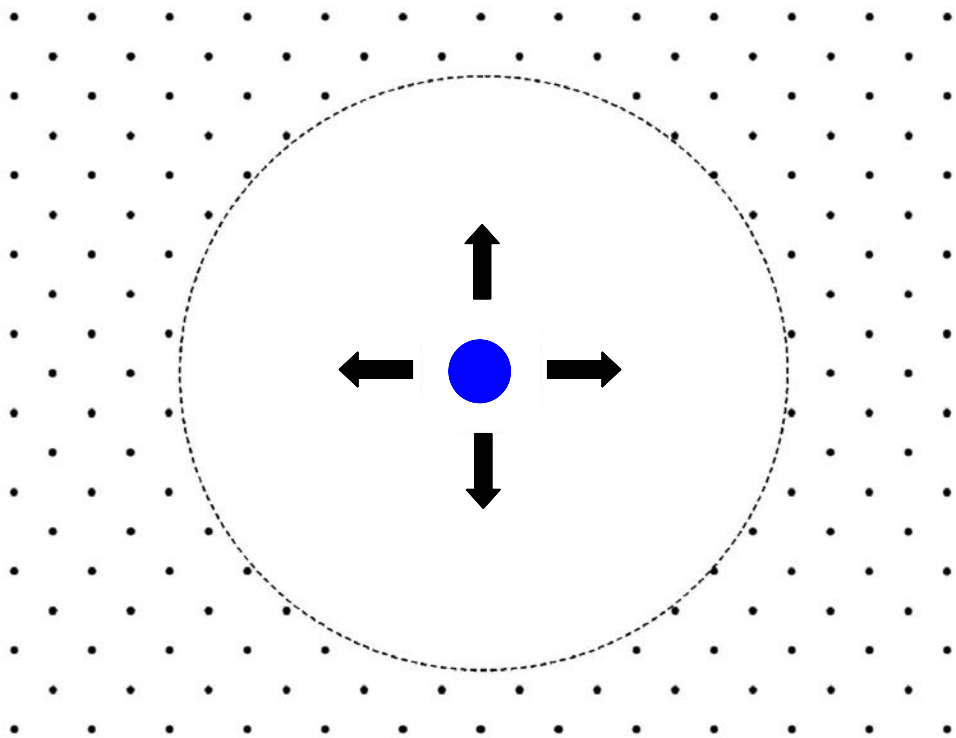

Figure 4: The Big Bang. The primeval atom explodes due to nuclear fusion reactions, producing primordial element abundance.

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

Also shown in this figure, the electromagnetic energy generated in the Big Bang traveled for billions of years out across the matter-depletion zone, until finally encountering the primal cosmic fabric “wall” beyond.

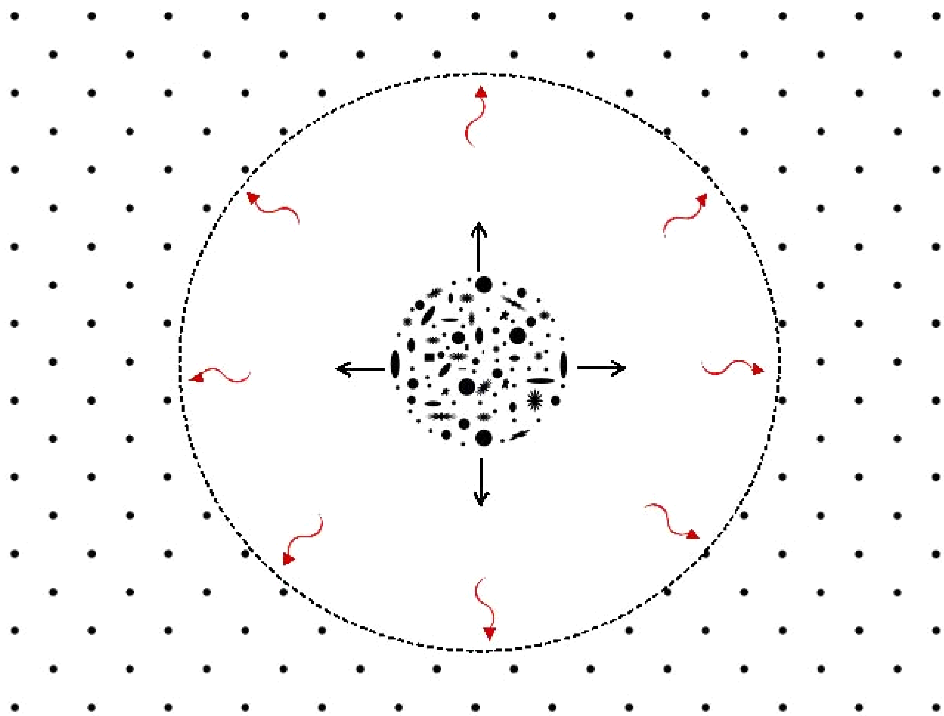

Figure 5: Remnants of the BEC are propelled into the matter-depletion zone as "cosmic shrapnel" as the universe expands (straight arrows). Energy produced by the Big Bang radiates out across the matter-depletion zone until it interacts with the surrounding cosmic fabric (wavy red arrows).

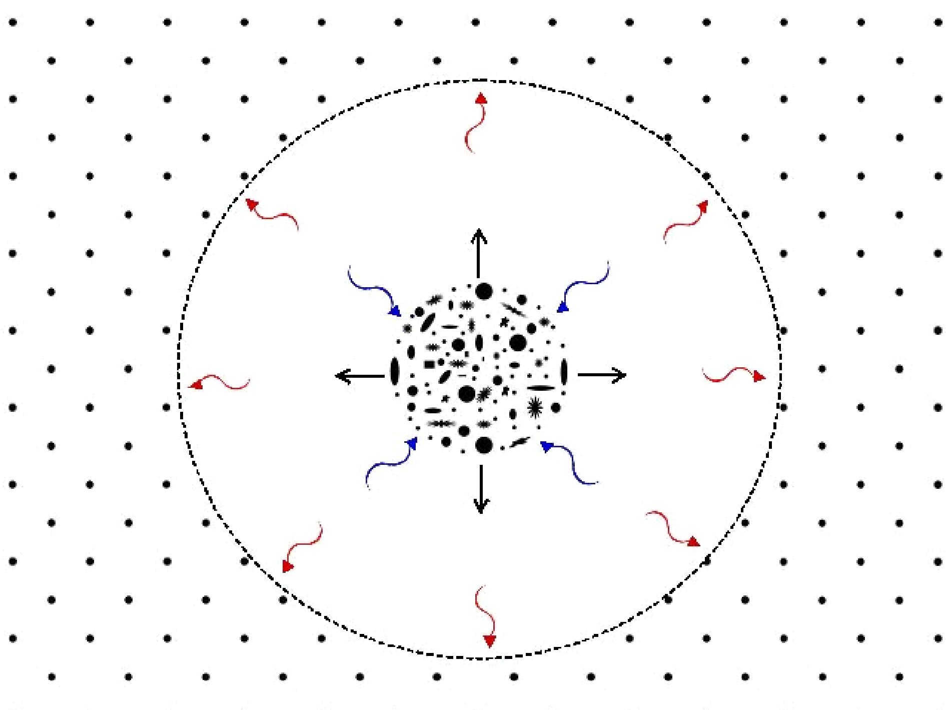

Figure 6: The surrounding cosmic fabric acts as a perfect black body, re-radiating the energy of the Big Bang at a lower wavelength (blue wavy arrows) back toward the locus of the explosion. The radiation impacts the still-expanding universe as cosmic microwave background (CMB) radiation.

As shown in figure 6, the peripheral cosmic fabric, at zero K, acted as a **perfect** blackbody, absorbing all of the energy, and re-emitting it as what we detect as the cosmic microwave background (CMB) radiation. Thus the CMB can legitimately be considered as a true "echo" of the Big Bang, not only as a picturesque figure of speech, but as a physical reality.

The soliton gravity waves generated by the Big Bang, also traveling at the speed of light, bounce off the cosmic fabric "wall" and back towards the expanding universe. The interference pattern, created as these waves bounce off opposite sides of the universe, gives rise to the periodicity of structure which has been detected in the universe over the last decade or so. These, and other, consequences of the ZKBB Big Bang will be addressed in more detail in future papers.

The "Primeval Atom"

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 [1]. This was as a result of his belief that the universe had evolved by a process similar to radioactive decay, which was a popular field at that time. If there was a primeval atom, and if it was a BEC, then it would truly act as a single quantum, and Lemaître's conjecture would be vindicated. With a universe beginning as a quantum object, perhaps finally there is 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 we look at the observational consequences of a Zero Kelvin Big Bang. First of all, the BEC is not the uniform, monolithic object that I had originally imagined. The central portion of mass may be a uniform condensed state, but the periphery is probably 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 determined how the universe evolved and dictated future observational reality. One property of a BEC is that of super-conductivity; an electric current initiated in it will perpetuate **forever**, with no decrease in energy. If it rotates, a super-conductor can create a permanent magnetic field around itself. Another property is that a BEC behaves as a super-fluid; it experiences zero viscosity, and therefore loses no energy as it moves. Also, a rotating BEC does not behave as a monolithic entity, but behaves as a collection of quantum vortices. It is most likely a combination of these quite unusual properties which ultimately determines what the universe looks like to us, many billions of years later. But this is getting ahead of ourselves, and will be covered in later papers.

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 depicted 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 almost indefinitely. But it did not. There was a Big Bang. Otherwise, we would not be here to try and figure out how it might have happened.

So, what might have occurred to upset this delicate balance, and precipitate such a monumental event? I would put forward the following scenario. I am not saying that this **is** the way it happened, but based on conventional physics, this is the way it **could** have happened; perhaps physicists with better insight than I can suggest alternative paths.

The initiating event may have been as simple as a “flip” of the electron on one of the atoms in the hydrogen cloud surrounding the BEC, resulting in the formation of a molecule of hydrogen (Figures 7 and 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 perhaps trillions of years (if years existed then), may have been such an event.

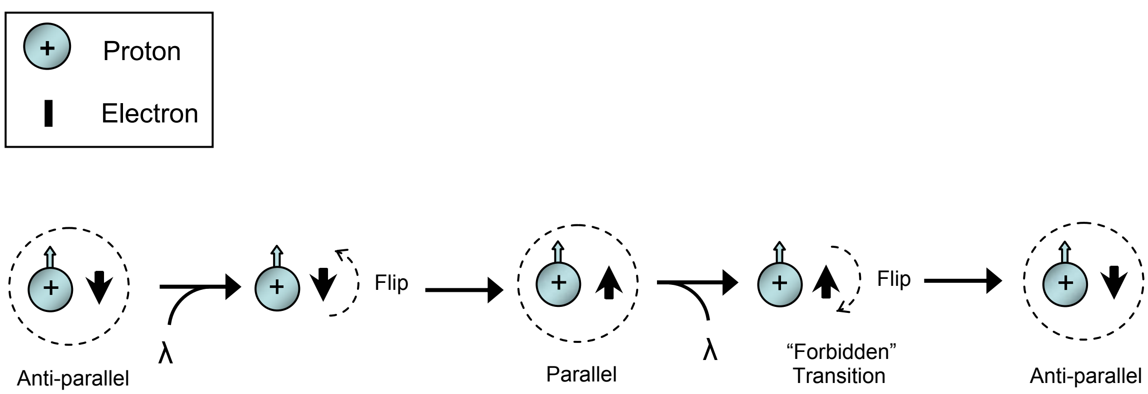

Figure 7: A spin-flip of hydrogen may have initiated the Big Bang. Only atoms with opposite electron spins (spin up and spin down, indicated by arrows) can form molecular hydrogen. The probability of a spin-flipped hydrogen reverting to its original state is so rare, it is called a “forbidden transition”.

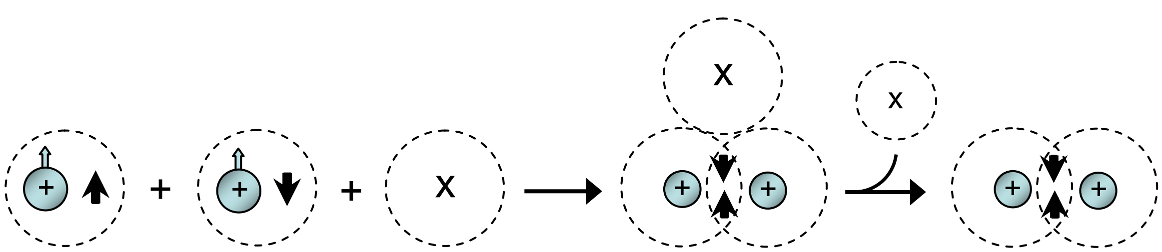

Figure 8: The three-body reaction which produces molecular hydrogen. Note that the reacting hydrogen atoms have electrons with opposite spins.

At the mass density of the 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 if you are patient and wait long enough (Figure 7). Even though an atom with a flipped electron would be free to react with an atom having opposite electron spin, at a low matter density the chance of two atoms contacting each other during this interval is essentially zero.

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” (Figure 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 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 the BEC, it did happen once, and we have ourselves and a universe to prove it.

The Big Bang

As suggested above, the initiating event for the Big Bang may have been as simple as a single spin-flip of the electron on one hydrogen atom. How could this simple, 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? Well, the reaction of two hydrogen atoms to form a hydrogen molecule releases a tremendous 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 adjacent atoms. This could start a kind of chain reaction, where each molecule formation reaction resulted in even more spin-flips, which resulted in further molecule formation, etc. This chain reaction effect might rapidly propagate around the entire shell of atomic hydrogen gas surrounding the BEC, where conditions were conducive to this process.

Even though hot hydrogen gas might be expected to expand in space, since it now had energy and therefore considerable pressure, the gravity of the BEC would tend to restrain an immediate expansion. Initially, one could envision an actual contraction or implosion. A hydrogen molecule inherently occupies less space than the combined space of the two individual hydrogen atoms. Therefore, the rapid conversion of this amount of atomic hydrogen to molecular hydrogen in the shell around the BEC would result in a sudden contraction of space around the BEC, **an implosion**. A terrestrial explosion, such as a thermonuclear fusion device (hydrogen bomb), is likewise triggered by an initial implosion, so this is not a foreign concept by any means. 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 the close proximity of hydrogen atoms in a high density BEC would facilitate nuclear fusion. The 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 velocities and rotations. In ZKBB theory, it is these residual fragments of BEC which eventually evolve into galaxies and other structures that we observe, out in space as far as we can see.

Temperature

One obvious question which any cosmologist might have: if not a temperature of infinity, how hot was the Big Bang? Here we have to use a little basic logic, and based on the ZKBB model, it goes like this. We start with a piece of matter at zero Kelvin, and consider it as a closed system. If one then converts some 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.

Let us start 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 is 0.75 (hydrogen) + 0.0625 (helium) = 0.8125 moles of matter

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

This energy released and applied to the residual mass would be 1.63×10^{11} J / 0.8125 moles = 2.0024×10^{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 2.0024×10^{11} J/mole / 34.9 J/mole/K = 5,737,530,000 K, or about **5.7 billion degrees** if all of the energy was released as thermal energy. Admittedly this is hot, but not infinitely hot, or even close to the trillion degree temperature sometimes mentioned in the SBB model.

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. In my estimation, one of the greatest missed opportunities in cosmology came in 1998, in a paper by Burbidge and Hoyle [2]. From the data on the cosmic microwave background (CMB), they showed that the total CMB energy was very 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, just as described for the ZKBB. Unfortunately, the authors were advocates of a 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 the most obvious process which fit the observations, they instead used the data to support 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 [3, 4, 5], 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, this event was creatively named a "bosenova". (Physicists are rarely at a loss for imaginative names).

It was hypothesized that the reason for this bosenova might 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 energy release, and a rebound explosion. I realize that 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, probably due to molecule formation, indicates to me that a similar mechanism for the beginning of the universe cannot be arbitrarily ruled out.

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 we 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, omega equal to one, and the flat rotation curves of spiral galaxies.

Acknowledgements

I would like to thank Dr. Isaac F. Silvera for helpful suggestions, and my daughter, Janine Gann, for expert editing and preparation of the figures.

References

[1] G. Lemaître, "Expansion of the Universe, The Expanding Universe", *Monthly Notices of the Royal Astronomical Society*, **91** (1931) 490.
[2] G. Burbidge, and F. Hoyle, "The Origin of Helium and the Other Light Elements," Ap.J. **509** (1998) L1-L3.
[3] J. L. Roberts, N. R. Claussen, S. L. Cornish, E. A. Donley, E. A. Cornell, and C. E. Wieman, "Controlled Collapse of a Bose-Einstein Condensate", arXiv:cond-mat/0102116v1 (2001).
[4] E. A. Donley, N. R. Claussen, S. L. Cornish, J. L. Roberts, E. A. Cornell, and C. E. Wieman, "Dynamics of Collapsing and Exploding Bose–Einstein Condensates". Nature, **412** (2001) 295–299.
[5] E. A. Donley, N. R. Claussen, S. T. Thompson, and C. E. Wieman, (2002), "Atom-Molecule Coherence in a Bose-Einstein Condensate", Nature **417** (2002) 529.