Zero Kelvin Big Bang, an Alternative Paradigm:

I. Logic and the Cosmic Fabric

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Abstract

This is the first in a series of papers describing an alternative paradigm for the history of the universe. The Zero Kelvin Big Bang (ZKBB) theory is compared to the prevailing paradigm of the Standard Big Bang (SBB), and challenges the notion that the universe is “all there is”. Logic suggests that the Big Bang was not a creation event, but that the universe did have a beginning: a “cosmic fabric” of pre-existing matter, in pre-existing space. Instead, the ZKBB was a transitional event between that “beginning” and our present universe. Extrapolating entropy back in time (as SBB does for matter and energy) and applying simple logic suggests a “cosmic fabric” consisting of the simplest, stable particles of matter, at the lowest energy state possible: singlet state, spin-oriented atomic hydrogen at zero Kelvin, at a density of, at most, only a few atoms per cubic meter of space, infinite and (almost) eternal. Papers II and III in this series describe formation of an atomic hydrogen Bose-Einstein condensate as Lemaître’s primeval atom, followed by an implosion-explosion Big Bang.

Keywords: Big Bang, Entropy, Cosmic Fabric, Spin-oriented Hydrogen, Bose-Einstein Condensate

Introduction

Albert Einstein is quoted as saying that, “Imagination is more important than knowledge”, and that may be true [1]. Unfortunately in recent cosmology, imagination appears to have almost obliterated reality, with “branes” and strings whipping around the universe in dozens of dimensions, and unidentified “non-baryonic dark matter” and “dark energy” dominating our existence. In this series of papers we return to reality, with a logical theory based on real matter, real physics and restrained imagination: the Zero Kelvin Big Bang (ZKBB). It is hoped that a combination of logic, imagination **and** knowledge will eventually lead to a better understanding of how the universe might actually have begun.

Stephen Hawking, in his 2003 talk “Cosmology from the Top Down”, framed the central question(s) of cosmology as why is the universe the way it is, and how did it get here? [2]. He argued that, “One shouldn’t follow the history of the universe from the bottom up, because that assumes there’s a single history, with a well-defined starting point and evolution”, and “The trouble is, there’s no natural boundary condition, like the universe being in its ground state. The universe doesn’t have a ground state”. While not challenging Dr. Hawking’s intellectual superiority, I do believe that he is incorrect on both counts. In this and subsequent papers, we will show how the universe may have arisen from a realistic ground state, and how it evolved via a single history, from a logical and well-defined starting point, to the universe we see today.

There have been many physicists over the years who have questioned the assumptions, mechanisms, or both, inherent in the Standard Big Bang (SBB) theory. Some have even gone as far as denying that such an event even occurred (*The Big Bang Never Happened*, Eric Lerner [3]; *Dismantling the Big Bang*, Alex Williams and John Hartnett [4]). Despite pointed critiques of implausible assumptions, questionable mechanisms, and ad-hoc additions to the theory, there have been relatively few attempts to advance a comprehensive, rational, alternative paradigm. We hope to rectify that deficiency here. In the absence of a satisfactory alternative, the SBB theory has persisted, with occasional modifications and ad-hoc additions (such as inflation, dark matter and dark energy) being made as contradictory observations arose.

We will not reprise the works of the many physicists who questioned both the assumptions and conclusions of SBB theory; those papers speak for themselves. Instead, in this series, we will propose an alternative paradigm, based on real matter, logical assumptions, and existing laws of physics. It requires no mystical "dark" ideas, or occasions when "the Laws of Physics do not apply". We will show how the ZKBB theory provides a plausible description of how the universe could have formed from a "cosmic fabric" of pre-existing matter in pre-existing space. The second paper will describe the formation of a Bose-Einstein condensate (BEC) from this matrix, Georges Lemaître's "primeval atom". The third paper will describe the Big Bang itself, an implosion-explosion of this BEC. Later papers will describe how contemporary observations are consistent with the physical consequences of the ZKBB, and how the outstanding problems in SBB theory, such as dark matter, dark energy, galaxy formation etc., are confronted and successfully addressed.

Because decades of work and tens of thousands of scientific papers have been invested in the SBB model, we do not expect immediate consideration or easy acceptance of the ZKBB hypotheses. This theory will rise or fall on its own merits, and not because of anyone's advocacy. It either fits **all** of the observations or it does not. However, I hope that physicists and cosmologists will take the time to evaluate their results relative to this alternative paradigm. If it is indeed correct, they may find that their results better fit a ZKBB scenario.

This theory is not some intellectual "silver bullet", worthy of a headline and a paragraph of revelation, miraculously solving in one step all the problems inherent in existing theory. Instead it is more like a thousand part jigsaw puzzle, where it is not the individual configuration of specific pieces which is important, but how a multitude of seemingly insignificant pieces fit together to form the final complete picture. Unfortunately it takes time to describe and explain each individual part of the puzzle, and observations which support the theory will have to be described, one-by-one, in later papers. So for now the theory will have to be supported by only the slender threads of logic and common sense.

Standard Big Bang (SBB) Theory

While called the **Standard** Big Bang theory, there are innumerable variations in use. In this series, SBB will refer to the following broad outline of a generally accepted sequence of conditions, mechanisms, and events.

1. Creation of all matter, energy and space *ex nihilo* (from nothing).

2. A starting condition of infinite density and temperature (a singularity?).

3. Matter and anti-matter created in almost equal amounts, with matter annihilation returning most of the energy, leaving a tiny surplus of matter as our universe.

4. A process of inflationary expansion which purportedly resolves problems with the SBB scenario (horizon problem, flatness problem).

5. Anisotropies in the cosmic microwave background (CMB) that reflect defects in this smooth, almost homogeneous, matrix which served as the “seeds” for future structure formation.

6. A process of “recombination” 300,000 years after the Big Bang, when the universe had cooled to 3,000 K, and complete atoms formed.

7. Continued but slower expansion and cooling of the universe, which allowed matter to gravitationally collapse around the “seeds”, and accrete or aggregate into the structures that we now see: stars, galaxies, galaxy clusters etc.

8. Approximately 80% of the matter in the universe consisting of unidentified and unexplained “dark matter”, most of it non-baryonic (baryonic being “normal” matter with which we are familiar, containing protons, neutrons and electrons).

9. For the past few billion years, the expansion of the universe has been accelerating due to “dark energy” which constitutes about 73% of the total mass/energy budget of the universe; this is also unidentified and unexplained.

SBB Assumptions

The SBB scenario relies on certain basic “bedrock” assumptions:

1. The universe is “all there is”; there is nothing “outside” the universe.

2. The Cosmological Principle. The universe is homogeneous and isotropic; uniform in distribution, and the same in all directions.

3. The Copernican Principle. We do not occupy a “special” position in the universe (like being at the center); the universe looks exactly the same from **any** location in the universe, and in **any** direction.

It will be suggested that all of these assumptions are suspect. ZKBB theory, using essentially the opposite assumptions, offers a more realistic scenario for the origin and evolution of the universe. In this paper we will primarily address assumption number 1.

Universe, Beginning Versus Origin

SBB theory envisions a universe with an “origin”, although its exact description is unclear and open to numerous interpretations, some even contradictory (was it an explosion or not?). Many cosmologists propose a mathematically derived “singularity”, infinite in density and temperature, originating from nothing, where “the Laws of Physics do not apply”. This description obviates the question, asked by naïve amateur cosmologists, “What came before the Big Bang?”. This question drew the well-known response from Stephen Hawking that it is like asking “What lies north of the North Pole?” [5].

I would contend that the original question is not as foolish as generally depicted. “Something” prior to the Big Bang is only ruled out because of assumption number 1 above, that our universe is “all there is”. Several respected main-line cosmologists (Silk, Rees, Albrecht, Tegmark, Linde) have already suggested the possibility of universes other than our own; so the assumption that ours is all there is, has already been professionally questioned. If there are other universes, what lies between them? If the miraculous, spontaneous appearance of our universe from “nothing” is open to question, then “something” existing prior to the Big Bang is possible. It is just that no one had any idea what that something might be. In this paper we will present a model which can just as easily and realistically support multiple universes as only one, without the need for supernatural phenomena.

ZKBB theory proposes that there are at least two entities, one embedded within, and derived from, the other. The first structure is the “cosmic fabric”, consisting of spin-oriented hydrogen atoms, at zero Kelvin, with a distribution of, at most, a few atoms per cubic meter of space, perhaps infinite in extent and almost eternal. The second, relatively small structure is our universe, which was derived from, and still lies embedded within the cosmic fabric. One may consider this a somewhat audacious claim, until one considers that this is only the latest (and perhaps last) logical expansion of man’s concept of the cosmos. Remember that less than a century ago, the prevailing consensus paradigm was that our galaxy, the Milky Way, was the **entire universe**. Hubble’s “island universes” put that belief to rest.

There was also a consensus that the universe was static, neither expanding nor contracting. Slipher, Lemaître and Hubble contradicted the latter view, and modern telescopes like the Hubble Space Telescope have shown fully formed galaxies like ours at least as far as we can now see, and an expansion which appears to be accelerating. So much for consensus! As Tim Eastman recently stated, “Science should not be confused with democracy and the popular notion that the theory with the most "votes" wins. [6]. There is no reason to believe that today’s consensus opinions are any better than yesterday’s. Some may believe that we are in a time of “precision cosmology”, and will see no further. But I think our present technology and theories will appear as quaint to future cosmologists as Galileo’s are to us.

In the ZKBB scenario, the Big Bang was not an **origin** event, as SBB theory would have us believe. Instead it was a **transitional** event between a pre-existing state (a part of the cosmic fabric) and the universe that we now observe. Since a universe with an origin appears to violate the First Law of Thermodynamics (matter cannot be created or destroyed), then the possibility of a “beginning” rather than an “origin” must be entertained. This may appear to be a semantic difference, but it is not. An origin in this case implies that there was nothing in existence prior to the Big Bang. A beginning implies that the universe arose from something which already existed. If there was already matter and space, then there may truly be an answer to what came before the Big Bang. Here we will describe exactly what this state might have been, and how the model is realistic from a scientific perspective.

Extrapolation

Extrapolation, projecting known information into unknown territory, is a key process in almost all fields of science. It can, however, face limitations and pitfalls if the correct assumptions are not applied. Here we will consider three extrapolations (matter, energy and entropy) as they relate to cosmology. The first two serve as the basis of SBB theory, but the third has been curiously overlooked.

Extrapolation of Matter

Perhaps one of the most significant extrapolations in cosmology was done by Georges Lemaître [7, 8]. Based upon evidence that the universe was expanding (from Slipher’s, Hubbell’s and his own work), he extrapolated back in time to conclude that all of the matter in the universe had once resided in a super-dense mass which he called the “Primeval Atom” or “Cosmic Egg”. From this beginning, he then hypothesized a smooth expansion of the primeval atom via radioactive disintegration of this single quantum, eventually leading to the present universe, an event depicted by Fred Hoyle as “one big bang at a particular time in the remote past” [9]. Hoyle created the Big Bang name, but it is Lemaître who can legitimately be credited as “the father of the Big Bang”; although it was George Gamow who was primarily responsible for the idea of an explosive, hot big bang.

Extrapolation of Temperature/Energy

In the second case, cosmologists extrapolated temperature back in time, just as they did with density. The logic was that confining a given amount of energy in decreased space would obviously increase energy density, and therefore temperature. Thus, if one extrapolated back in time to a universe compressed to infinite density, one would expect a concurrently infinite temperature. This picture is, however, questionable because it is based on the unwarranted assumption that matter **always** had energy.

Prior to a Big Bang energy release, it is perfectly plausible that one could have an entity of condensed matter with no energy at all; matter at zero Kelvin or absolute zero. Matter is converted into energy all the time, either spontaneously as with nuclear fission, or by nuclear fusion as in the sun, where millions of kilos of matter are transformed into energy every day. The converse, transformation of energy into matter, is highly improbable due to the high energy required, the matter-antimatter problem, and the seeming violation of the Second Law of Thermodynamics. Thus, matter without energy is a quite plausible starting condition, whereas energy without matter is not.

Extrapolation of energy backwards in time, to a state of infinite temperature, was primarily the idea of George Gamow, who envisioned **all** of the elements being created in the Big Bang [10]. Other physicists later demonstrated that only hydrogen, helium, and a tiny amount of lithium would emerge from this process. The Burbidges, Fowler and Hoyle (B2FH) [11] and others showed how the elements between helium and iron would be formed in stars, and how the elements heavier than iron would originate in supernovae explosions. Even though most physicists accepted the fact that an infinitely hot Big Bang was no longer essential for total nucleosynthesis, they nevertheless still clung to the assumption of a **HOT** Big Bang. This dogma has had a devastating effect on the ability to consider alternative scenarios, despite the increasing number and severity of “anomalies” exposed by subsequent observations. In ZKBB theory, we will show how an initial high matter density may be unavoidable, but an infinite temperature is definitely not.

Extrapolation of Entropy

The third extrapolation, and one which has been curiously overlooked or avoided, is that of entropy. Even though all cosmologists concede that the universe must have begun with extremely low entropy, **zero** entropy seems to have not even been considered by most physicists. Scientists have tended to tiptoe around the whole topic, because the logic encapsulated in the Second Law of Thermodynamics was incompatible with essentially all universe theories. It is here that we can see the first inkling of an alternative paradigm, radically different from that of the SBB theory and others. Let us follow the logic of this process.

Entropy and Logic

Even those with little formal physics education are cognizant of entropy, and the Second and Third Laws of Thermodynamics. The Second Law states that the entropy of a closed system can only increase, and the Third Law states that zero entropy occurs only in a perfect crystal at a temperature of zero Kelvin, absolute zero. If the entropy of the universe (a closed system in SBB theory) can only increase with time, then extrapolating backwards in time, as Lemaître did with matter density, irrevocably leads to a condition of zero entropy at the beginning of the universe. Here there is no energy whatsoever, only matter; so maybe that is where the universe began.

This is obviously in stark contrast to the “infinite” temperature, and presumably infinite entropy inherent in the SBB model. A legitimate question for SBB theory is this: if entropy appears to be close to a maximum in the SBB event (a “seething sea of sub-atomic particles”, at infinite temperature), how can entropy possibly increase from there, as circumscribed by the Second Law? In ZKBB theory, the universe starts at zero Kelvin and zero entropy, so it is hardly surprising that entropy increases with time. Here perhaps, at last, is the secret key connecting entropy and the arrow of time; **both began at zero** prior to the Big Bang. Entropy increases as energy is released in the Big Bang, and subsequently by nucleosynthesis in stars. There is undoubtedly some moderation of the entropy increase by the cooling of the universe, but this is counterbalanced by universe expansion and the diffusion of the matter within.

The Third Law of Thermodynamics requires that matter with zero entropy be the equivalent of a perfect crystal, a quantum entity with only one degree of freedom. It is somewhat amazing that Georges Lemaître actually proposed this single quantum state for his primeval atom in 1931 [12]. Even more amazing is that modern physics can actually describe, **and demonstrate**, an entity like this; a Bose-Einstein condensate (BEC). In a BEC, each individual atom is indistinguishable, and the whole entity behaves as if it were a single atom, in effect a perfect crystal. In ZKBB, this BEC, this single quantum, is composed of "spin-oriented" atomic hydrogen, as will be described in this and the following paper.

A Cold Big Bang

The idea of a cold Big Bang, as opposed to the prevailing hot Big Bang, is neither original nor unique. Several well respected physicists, such as Zeldovich [13], Layzer [14], and Aguirre [15] have suggested the possibility of a cold beginning for the universe. Unfortunately, in most cases, the identity of the cold "something" was not identified, or the evolutionary processes leading up to our universe were inconsistent with observations e.g. the isotropic Cosmic Microwave Background (CMB). However in the case of the ZKBB, we now have an exactly specified starting condition (cosmic fabric), and processes which logically and naturally result in the phenomena that we observe in the universe, both qualitatively and quantitatively.

Hydrogen

If logic suggests a beginning at zero Kelvin, then what exactly existed at zero Kelvin? And by what mechanisms and processes had it managed to morph into the universe that we see around us? Harlow Shapley, who first determined our position in the Milky Way, is quoted as saying, "Some piously record 'In the beginning God', but I say 'In the beginning hydrogen'". I think that he was absolutely correct. If one accepts the initial premise, from the extrapolation of entropy, that the universe might have begun with zero energy at zero Kelvin, simple logic would suggest the simplest possible building block: atomic hydrogen, at its absolutely lowest energy level.

In our universe, hydrogen in its various forms is predominant at about 74%, with 24% helium, and only minor amounts of the other elements. Basic physics suggests that all complex nuclei (ones with neutrons) can originate from atomic hydrogen, by some process or series of processes. Even the unidentified and unexplained "dark matter", "missing" matter invoked to solve problems with SBB theory, has been hypothesized as various forms of hydrogen [16, 17]. In a later paper we will show that these ideas are most likely correct.

Atomic hydrogen is the simplest atom there is, consisting of only a single proton and a single electron. With a little imagination one can see that all of the other elements could be formed from this simple building block, via neutron formation (proton + electron > neutron + antineutrino), neutron capture (hydrogen + neutron(s) > deuterium and tritium), and nucleosynthesis (4H > 1 He). Atomic hydrogen is extremely reactive under terrestrial conditions, and spontaneously converts to molecular hydrogen, H_2. However at a temperature close to zero Kelvin, if the electrons all have the same spin (spin-oriented), atomic hydrogen is extremely stable and unreactive. This is due to the Pauli exclusion principal: only atoms of hydrogen with opposite electron spins can combine to form a molecule of hydrogen, H_2.

The hydrogen atom is also extremely stable. A couple of decades ago, most physicists subscribed to the trendy paradigm known as Grand Unified Theory (GUT); at that time it was an integral component of SBB theory. Even though shown to be wrong, elements of it still show up in explanations for the origin of the fundamental forces. Erroneous theories do not die easily or quickly. One prediction of the GUT was that the hydrogen atom would eventually disintegrate. Millions of dollars and hundreds of man-years were spent on experiments watching for the predicted light flashes from this event, occurring in giant tanks of water in underground caverns below thousands of feet of rock. Tellingly, none were ever seen, and it was concluded that hydrogen was stable for at least a trillion trillion years (perhaps forever), and that GUT was wrong. So it is that many consensus theories eventually turn out to be wrong, sociology only temporarily impeding scientific progress.

Rather than a fanciful theory, one can use logic to hypothesize that the primeval matter (prior to a Big Bang) was, in fact, atomic hydrogen. The simplest, stable unit of matter (atomic hydrogen), at its lowest possible energy state, with zero energy and entropy (zero Kelvin) thus becomes a seemingly rational place from which to launch a universe, and this is the starting point for the ZKBB theory. If this premise is at all valid, then what can contemporary physics tell us about this initial state?

The Cosmic Fabric

Prior even to the beginning of the beginning of the Big Bang, ZKBB theory envisions a "cosmic fabric". This appears less of an arbitrary, ad-hoc assumption, when one realizes that the eventual consequences of this starting point are consistent with predictions of standard physics, and a final physical reality supported by observational cosmology.

Obvious questions and answers are:

Q. Where did the hydrogen come from? By negating the Big Bang as an origin, aren't you just moving the origin further back in time?

A. I don't think the hydrogen came from anywhere. I think that it had always existed and, far outside the sphere of our universe, will continue to exist.

Q. How could the cosmic fabric have been at equilibrium, and essentially eternal, until the Big Bang? Wouldn't it spontaneously collapse by gravity as envisioned by Isaac Newton 400 years ago?

A. The cosmic fabric would initially appear eternal and at equilibrium because there was no energy, the hydrogen atoms were unreactive, and probably mutually repulsive, thus precluding gravitational collapse. An appreciation for these unusual properties of the cosmic fabric requires an understanding of "spin", and the physics of atomic hydrogen. I will attempt to provide that here.

Which Hydrogen?

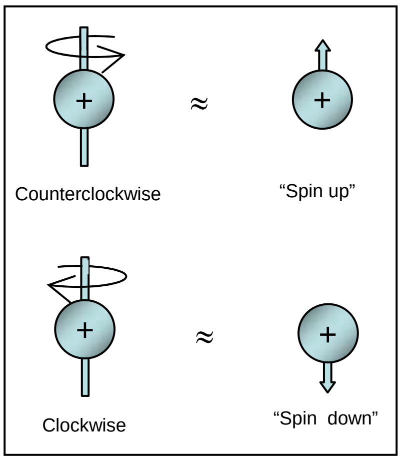


Figure 1: Spin-oriented proton

The elementary particles of atomic hydrogen, proton and electron, have the property of "spin". This can be visualized (but not described) as being like a spinning top; spinning clockwise/counter-clockwise, or with spin up/spin down (Figure 1). The latter picture is easier to diagram so that is the one I will use. The designation of up or down is arbitrary but should be consistent. Because of the spin of the two elementary particles, proton and electron, atomic hydrogen can have four different spin configurations, as shown in Figure 2.

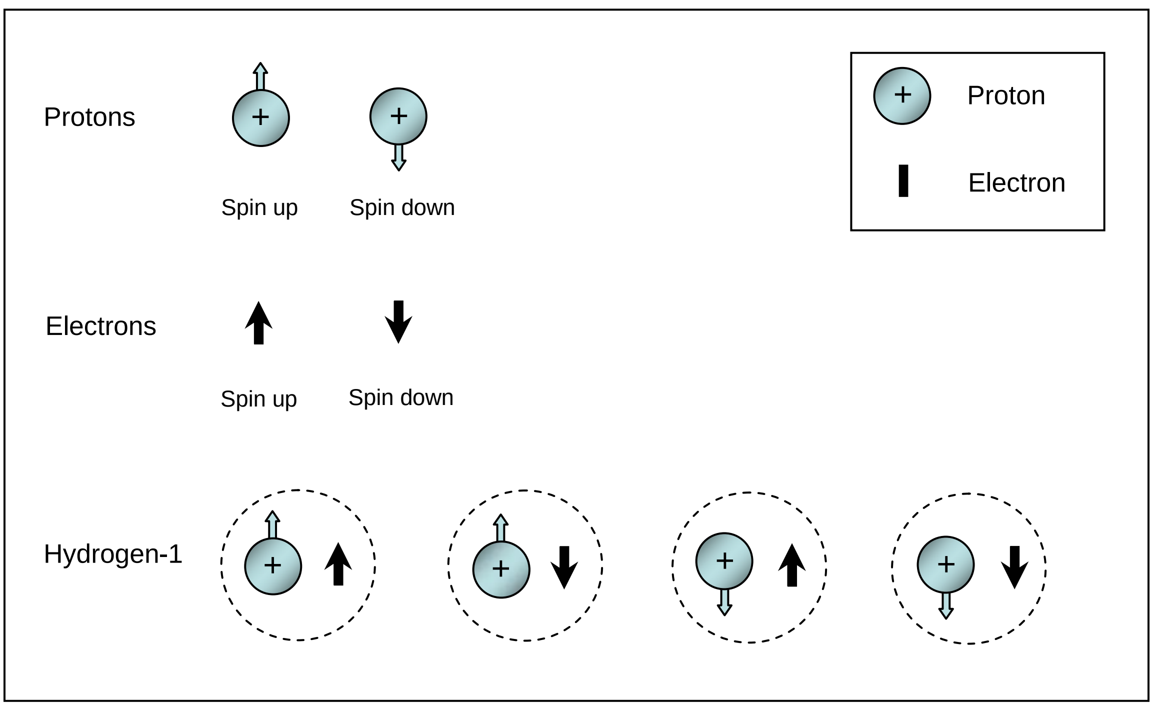


Figure 2: The spin configurations of atomic hydrogen

These are shown as (electron-proton) up-up, down-up, up-down, and down-down. One might think that the down-up and up-down configurations (both with total spin zero) might be equivalent, but they are not. This was first shown by Satyendra Nath Bose, an Indian physicist, in 1924 [18], with his discovery of what became known as Bose statistics. These statistics govern the behavior of bosons (also named after Bose), particles which have zero or integer spins (-2, -1, 0, +1, +2). This is in contrast to Fermi statistics (named after Enrico Fermi) which govern the behavior of fermions, particles with fractional spins (-3/2, -1/2, +1/2, +3/2). The proton and electron are both fermions with ½ integer spins (+1/2 or -1/2), but when they are together in the hydrogen atom, the total spin is an integer (-1, 0, 0, +1) as shown in Figure 3. Hydrogen atoms are therefore bosons, and it is this property which will lead to a universe.

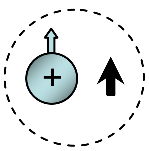
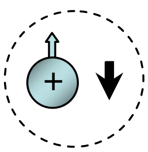
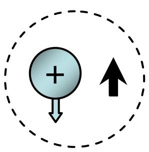
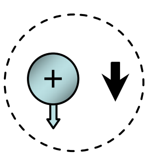
Hydrogen-1	**Configuration (electron, proton)**	**Spins (electron, proton)**	**Total Spin**
	up, up	+½, +½	+1
	down, up	-½, +½	0
	up, down	+½, -½	0
	down, down	-½, -½	-1

Figure 3: Spin states of atomic hydrogen

When I first hypothesized atomic hydrogen as the primeval matter, logic immediately suggested either the up-down or the down-up atom as the likely culprit. In these cases the electron spin and proton spin effectively cancel each other out, resulting in a spin of zero, and a lower energy state. But, then, which of these two configurations was the right one, and what prevented the aggregation or premature collapse of this structure? The answer to both questions came in a diagram, in papers by Isaac F. Silvera [19] and the Ph.D. thesis of Dale Fried [20]. An adaptation is shown in Figure 4.

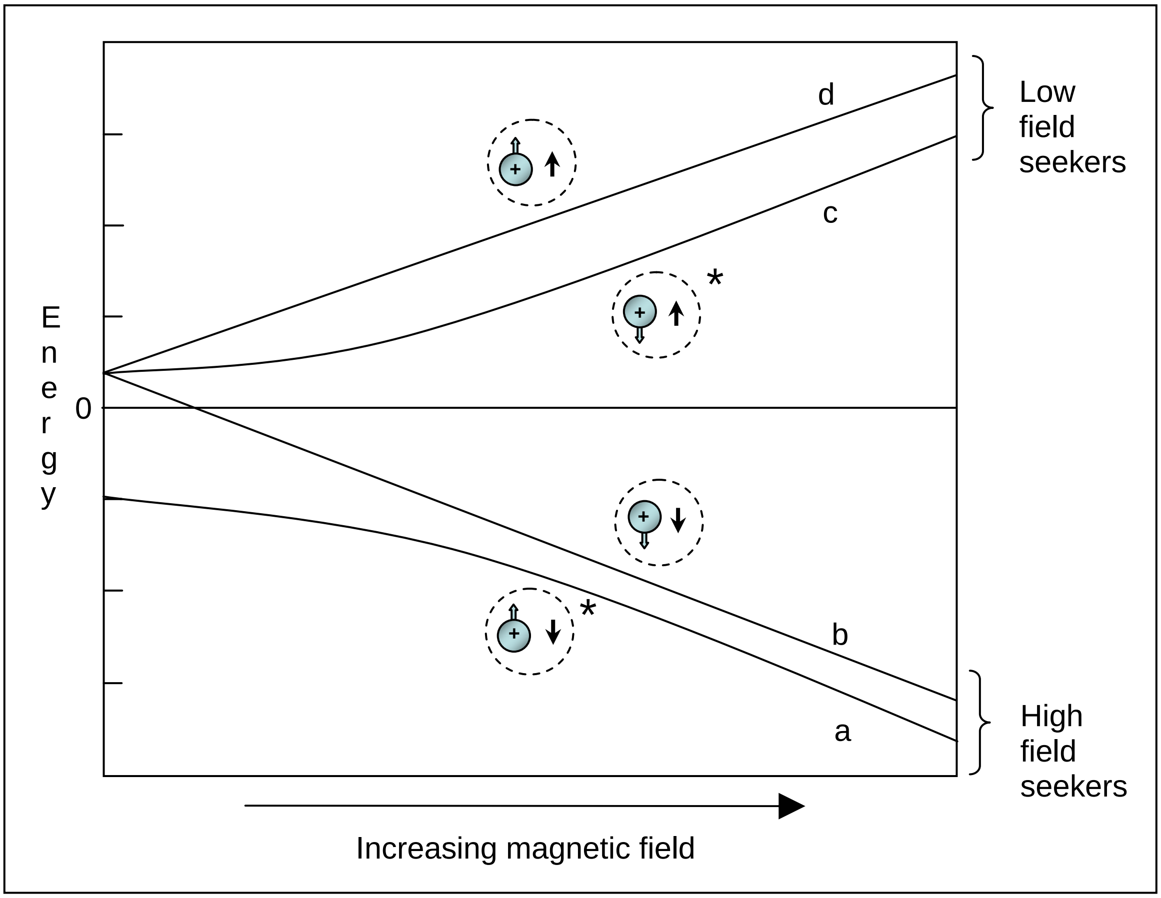


Figure 4: Energies of the hydrogen hyperfine states as a function of magnetic field. *Adapted from Silvera [19] and Fried [20].*

This shows the energy of hydrogen atoms subjected to a strong magnetic field, which interacts with the spin or magnetic moment of the protons and electrons. Atoms with “down” electrons (a and b) are known as high field seekers and congregate where the magnetic field is the highest. Atoms with “up” electrons (c and d) are low field seekers and are repelled by the field. Looking carefully, one can see that there is a difference in the vertical axis intercept between the “a” atoms (down-up) and the “c” atoms (up-down), even though they have the same total zero spin. The “a” atoms, the **singlet** state, show a negative intercept or negative energy relative to the **degenerate** “b”, “c” and “d” atoms, at zero magnetic field. This was a “Eureka!” moment for me. In physics, negative energy is synonymous with **repulsion**. Was it possible that the “a” atoms might be even slightly mutually repulsive? If they were, this could be why the cosmic fabric did not spontaneously collapse due to gravity. Whatever gravitational attraction there might be between adjacent atoms could be compensated by mutual repulsion. If correct, a cosmic fabric of exclusively singlet state “a”, down-up atoms, would be (almost) eternally stable.

Now this was finally a rational beginning ground state from which a universe could evolve; atomic hydrogen “a”, at zero Kelvin. In the second paper of this series, we will consider the breaking of this equilibrium state, and the condensation of the atomic hydrogen into a Bose-Einstein condensate (BEC), Lemaître’s primeval atom. We will see that mutual repulsion is also a prerequisite for the formation of this entity.

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