The Formation of the Universe as a Crystallization Process and the Origin of Gravity

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Abstract

During the Big Bang which signaled the origin of the Universe, electrons and protons, which are particles, were formed from a pre-Big-Bang energy source. In this process of particle formation, energy was conserved. This process represents and is modeled as a phase transfer or crystallization process.

In order to model the Big Bang, three processes are discussed: (a) origin of the pre-Big-Bang energy singularity, (b) the process of electron and proton formation, (c) and the continuing mass-loss of the Universe. It is shown that (a) and (c) are intimately related.

From the initial state of an energy singularity, a nucleation-growth process for the mass formation of the Big Bang is suggested. This process leads to a suggestion for the origin and properties of gravity. Gravity appears as the counter-energy for mass and standard energy. Thus, the model suggests that gravity is anti-energy, and conversely, that energy is anti-gravity. It leads to an explanation of the observed association of mass and gravity. The process negates the need for the formation of antimatter as a balance to regular matter during the Big Bang.

The process predicts that mass-gravity decays proportional to radiative mass to energy conversion. The predicted decrease of gravity with time predicts a non-linear expansion of the Universe, of galaxies, and of planetary star systems with time.

Photons, the product of radiative mass loss, carry twice the gravity of the originating mass due to relativistic gravity doubling. This suggests photon-graviton duality during mass to photon conversion. Due to photon formation, overall gravity increases with radiative mass loss.

The model presents an alternative for the expansion and re-assembly of the Universe relative to the proposals of hypothetical dark matter (re-assembly) and negative energy (expansion).

Introduction

'The state of the Universe before the Big Bang and its cause are not known - will not be known - can not be known. Only God knows.' These seem have to become faith statements of the scientific community. One of the reasons is that the backward - extrapolation of the Hubble relation cannot exceed the limiting 10^{-43} seconds imposed by Planck time.

The present approach to model the Big Bang as a crystallization process of pure energy to particles is an alternative approach to previous models. This model is not based on back-extrapolation, but starts before the Planck era with an energy singularity. The present model results from observations of astronomical and well accepted physical processes, and includes fundamentals based on the theory of relativity.

It is generally accepted that the Universe originate from a pre-Universe energy singularity by a process which is referred to as the Big Bang. The outcome of the big-bang process is the formation of mass, where stable electrons and protons form the present mass-Universe. The third form of observed semi-stable mass particles is neutrons, which are only stable in atomic nuclei. Free neutrons are labile and dissociate into electrons and protons.

In the course of the Big Bang, electrons, protons, and neutrons condensed into atoms. These are concentrated into stars, a process that is continuing. Stars may have planetary companions like the solar system. Stars are gathered in galaxies, and galaxies are grouped into clusters, which are grouped into super-clusters separated by vast distances of empty space. The sum of galaxies forms the Universe.

Astronomical evidence shows that the Universe is expanding by some unknown process. A hypothetical pulling force, called ‘negative or dark energy’ has been proposed to cause the expansion.[1] Non-baryonic matter, called

'dark matter' has been proposed to provide the gravitational energy for an eventual collapse of the Universe. Both negative energy and dark matter have been invoked to explain observations in distant galaxies.[2,3,4] They have not been observed under laboratory conditions. The present model leads to explanations of the expansion of the universe and its eventual collapse by known and experimentally verified mechanisms.[5]

Four forces or interactions govern the Universe: gravity, the electromagnetic force, the strong nuclear force, and the weak interaction. In addition, time forms an integral part of the Universe. Models have been proposed that combine these interactions, except gravity.

In 1905, Einstein published the special theory of relativity to model the status of the Universe. The theory states that the only constant in the Universe is the speed of light in vacuum. A fundamental equation that emerged from the theory is equation (1).

	$\mathbf{E = mc^2}$	(1)

Here energy (E, ergs) equals mass (m, in g) multiplied by the square of the speed of light (c, cm/s^2). This equation establishes the equivalence between mass and energy and is an essential part of the present model.

In 1915, Einstein devised the General Theory of Relativity. He observed that the effects of gravity and acceleration are indistinguishable and therefore equivalent. He suggested that gravitational forces are linked to bending of space-time. Einstein's theory suggests that any object bends the space-time that surrounds it. In the case of an object with relatively large mass, such as a star, this bending can cause a change in the path of anything passing near to it including photons. These and other predictions were experimentally confirmed. However, this model does not provide causality for the existence of gravity, nor its connection to mass and energy. Until now it has been elusive to provide a causative relationship with the other known energies.

To match the predictions of the general theory to astronomical observations, Einstein introduced an adjustable parameter, the cosmological constant. Depending on its magnitude, Einstein's model predicts an expansion, a collapse, or a steady state for the end of the Universe.

The theory of relativity did not solve the problem of the state before the Big Bang and its origin. Similarly, gravity was taken as a not-yet-explainable property of matter or space. Time was introduced as a fourth dimension to the observable three dimensions of lengths, area, and volume. Within this logical framework, it was defined as a length and its unit as the distance that light travels during a second in vacuum.

Some fundamental cosmological science question remain

- The origin and the destiny of the Universe
- The origin and the process of the Big Bang
- Origin of gravity and its relationship to other forces
- The apparent lack of matter to reverse the observed expansion of the Universe, and the uncertainty of invoked 'dark matter'
- A process by which 'dark matter' increases as regular matter is lost by thermonuclear reactions in stars
- The observed acceleration of the expansion of the Universe and the invoked 'negative force' which 'pulls' the Universe apart (dark or negative energy)

- The source and properties of this negative force outside the Universe
- The observed disintegration of galaxies
- The absence of antimatter to balance the existing 'normal' matter

It appears that the present models of the Universe are at an impasse to explain a multitude of these experimental and conceptual questions. Answers have been sought by inspecting existing models and theory. While existing models and theories may provide answers, it is also plausible that answers may come from a change of focus and an inclusion of new and different ideas. The present paper tries to do the latter and proposes a working hypothesis to model the origin and the destination of the Universe that is in agreement with astronomic and other observations. It suggests answers to many of the above questions, and leads to quantitative models and predictions that can be confirmed by experiments and astronomical observations.

Before the working hypothesis can be proposed it is necessary to review the present knowledge of the status and of the destiny of the Universe. Out of necessity, this can and will not be comprehensive.

Formation Models of the Universe

Two major models for the formation of the Universe are the steady state and the Big Bang models.

The steady-state Universe proposes that new matter is continuously created in order to maintain constant density. There appears presently no experimental observation that supports a continuous formation of new matter, and this model will not be considered in the present context. The proposed working hypothesis supports the experimental observations that under the present conditions formation of new mass is highly unlikely.

The Big Bang model proposes that the Universe is expanding from a single explosive formation of matter. This is presently the leading model for the beginning of the Universe. It is derived from the observation and extrapolation that the galaxies appear to spread away from a single time/space point. Extrapolation of the present expansion to this origin suggests that all galaxies and thus all mass originated at a specific time and at a specific location. This time/space is associated with a massive formation of mass. The observations leading to the Big Bang model do not yield a rationale for the state before its beginning, that is, the causes and the source for the mass formation, and the destiny of the Universe. It was suggested, based on the Big Bang model that antimatter should exist in equivalent amounts to so-called normal matter. The Big Bang model does not account for the absence of antimatter in the Universe.

Another conceptual and theoretical problem is the existence of gravity. It has not been possible to link gravity to the other observed energy forms. Gravity is always associated with mass, but there is no model that explains how and why. The present state of the Big-Bang model does not give information about the formation of gravity, and how it relates to the other energies or forces.

A fundamental question left open by the Big Bang model is the lack of a mechanism that explains the origin of the Big Bang itself. The big crunch model was proposed to answer this question, but recent experimental evidence for an accelerated expansion of the Universe puts this model into doubt.

The question following the formation of the Universe is its destination. Three processes have been proposed.

Models for the Destiny of the Universe

Three major models for the destiny of the Universe have been proposed and have gained favor at different times.

The Big Crunch model

This model assumes that the gravitational force of the Universe is greater than the centrifugal forces and greater than the proposed negative energy that is suggested to drive it apart. It is suggested that the gravitational force will eventually cause the direction of the present expansion to reverse.

Under this assumption, the big crunch model predicts that all mass of the Universe will return to the time/space of the initial Big Bang. The mass will crunch together, and that from this crunch, a new Big Bang will be created. The Universe will alternate between Big Bang expansion and big crunch contraction.

One of the present questions and inquiries is, if there is enough mass in the Universe to provide the necessary gravitational force to stop the expansion and to revert to contraction. Experimentally, astronomic observations presently do not provide evidence for the existence of enough mass. This has triggered a massive search for the 'missing mass' also referred to as 'dark or black matter' from both astronomical and theoretical aspects. It has been estimated that the Universe must contain as much as ninety percent of dark mass to reverse its direction from expansion to contraction. The properties of the proposed matter are not understood except that it must exert a gravitational force.

Another concern is that the predicted slow-down of the expansion of the Universe appears to be contradicted by astronomic observations. To the contrary, observations appear to indicate that certain galaxies accelerate away from the ‘center’ of the Universe. This has led to the suggestion that there is a 'dark’ or ‘negative’ force (or energy) outside of the Universe which pulls the Universe apart. [6] The origin and source of this dark force are not known.

The Inflationary Expansion model

Less effort appears to be expanded into a model for the end of the Universe, where there will be no big crunch. Instead, it is considered that the centrifugal forces in the Universe are not overcome by gravity, and the Universe will expand forever. This view is in agreement with the present observation that not enough mass has been observed in the visible Universe to cause a reversal of the expansion and a big crunch, and that there is no evidence for a slow-down of the expansion.[6]

This model has gained favor by the observation that certain galaxies appear to accelerate away from the center of the Universe. This creates the problem to explain the energy for the observed acceleration. 'Dark’ or ‘negative’ energy has been proposed, but the source and the properties of this energy are not understood.

Here, the problem of the origin of the Big Bang and the final fate of mass and energy are left open. The postulation of dark energy outside the Universe creates another conceptual problem. In its present state, this model does not predict an alternation between Big Bang and expansion.

Based on the big expansion model, Linde proposed a self-reproducing model for the inflationary Universe. He asserts that 'instead of being an expanding ball of fire, the Universe is a huge, growing fractal. It consists of

many inflating balls that produce new balls, which in turn produce more balls, ad infinitum'. [7] Physical and astronomic tests for this model are uncertain.

The Great Stand-Still Model

This model is generally not much considered. However, it is discussed to complete the list of models. It is an intermediate between the big crunch and the big expansion models. It assumes that the gravitational and centrifugal forces eventually will come to equilibrium. The expansion of the Universe will slow and come to a halt. At the point of the great standstill neither further expansion nor contraction will occur.

As with big crunch model, this model predicts a slow-down of the expansion of the Universe which has not been experimentally been verified. It is further complicated by the observed accelerated expansion of the Universe.

Further, in agreement with the predictions of the big crunch model, not enough mass has been observed in the Universe to experimentally support the gravitational slowdown of the expansion and the standstill of the expansion. The problems of the 'dark mass' also apply to this model. As with the other models, the origin and process of the initial Big Bang is not explained.

This is not the place to review all the arguments brought forward for and against these models. However, it seems clear that each one has its own predictions and limitations. At present, experimental evidence appears not to fully support either of the proposed destinies of the Universe.

New: Phase-Transfer (Crystallization) Model

The present paper suggests an alternate model from the above hypotheses. The model provides suggestions for the state of the Universe before the Big Bang, a mechanism that led to the Big Bang, the process of the Big Bang, and the probable destiny of the Universe. Its suggestions, which are based on experimental facts, suggest additional understanding of the present state of the Universe. The working hypothesis suggests answers to questions like the origin and properties of gravity, the lack of antimatter, and the apparent deficiency of mass (dark matter), and of the mysterious 'dark energy'. It quantitatively models the observed acceleration of expansion.

The experience, previous work, and publications on the mechanism of crystallization led to the suggestion that the Big Bang may be considered analog to other phase-transfer processes, specifically, crystal nucleation processes. [8] The concept is based on the understanding that pre-Big-Bang energy was converted to mass particles, which represent an alternative form of energy.

This analogy, however, needs further narrowing. Thus, nucleation and growth processes will be reviewed in greatly simplified sketches before the new hypothesis will be suggested.

Nucleation and Growth Processes

The Big Bang process consisted of the conversion of energy into mass by nucleation and growth processes. The initial problem is thus the mechanism of mass-formation. Such processes are commonly known as nucleation and growth crystallization processes. They generally apply to the formation of particles (crystals, drops) during a phase transition. A phase transfer where particles are formed is referred to as crystallization. The author developed a comprehensive balanced growth and nucleation (BNG) model that aims to combine and extend the

present knowledge for material nucleation and growth. [8] It is this work on the BNG model that suggested the present model for the origin and destiny of the Universe.

Nucleation may occur in two different mechanisms, which are of interest for the present discussion, multi-center and single-center.

Multi-center Nucleation

Association of different centers forms nuclei of the product. A common example is the crystallization of salt (NaCl) from solution:

	$Na^+ + Cl^- \Rightarrow NaCl$	(2)

Another multi-center nucleation is that of potassium-aluminum sulfate (alum)

	$K^+ + Al^{3+} + 2\ SO_4^{--} \Rightarrow KAl(SO_4)_2$	(3)

Here, four centers are involved in the formation of the basic crystal block.

If one considers the initiation of the Big Bang, one might consider that it was caused by the association of two or more pre-centers as discussed above. In that case, it might be expected that the contributions of the different originating center would be observed in the present Universe, similar to the detection of the components of the crystallization examples discussed above.

For the origin and properties of Big Bang, additional assumptions for the origin would have to be made for these pre-centers. It appears that the Universe is homogeneous in its composition, which makes this type of nucleation unlikely. The multi-center origin of the Universe opens more questions than it solves, is appears highly unlikely, and thus is not considered.

One-Center Nucleation

This type of nucleation may be exemplified by several examples, the crystallization of sugar, and the condensation of water and helium. Sugar molecules aggregate at high concentration from solution to form sugar crystals (equation (4).

	$n\ C_{12}H_{24}O_{12}$ (dissolved) $\Rightarrow (C_{12}H_{24}O_{12})_n$ sugar crystal	(4)

Condensation of snow flakes is another well known example for one-center nucleation (equation (5)).

	$n\ H_2O$ (gaseous) $\Rightarrow (H_2O)_n$ liquid / droplet	(5)

A further example is the condensation of helium to liquid helium at low temperature (equation (6)).

	n He $\Rightarrow$ He_n liquid / droplet	(6)

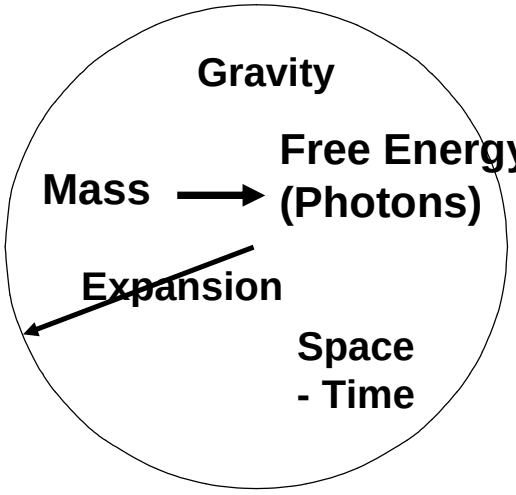
The formation of mass (crystalline energy) from pure energy in the present Universe is considered a variation of this concept.

The association of energy to mass is a reversal of the present observation of the radiative conversion of mass to energy.

The Present State of the Universe

The present state of the Universe is very complex in its details and interactions. However, certain basic features can be discerned (Figure 1).

Figure 1: Present State of Universe



The basic properties of the Universe consist of space, gravity, energy, mass, and time. Important processes are mass to energy conversion, motion, and expansion.

Space

Space is observed by the separation of mass-centers. The origin of space and its intrinsic properties appear not to be understood. Its meaning is ambiguous if there are no separate masses present to show its presence. The presence of space is considered a self-evident fact.

Gravity

Gravity is the force that holds planetary star systems, galaxies, and the Universe together. The larger the masses of two objects, and the closer they are together, the stronger the gravitational attractive force, F, will be as given in Equation (7).

$$F = \frac{GM_1M_2}{R^2} \qquad (7)$$

Here, G is the universal gravitational constant, M_1 and M_2 are two interacting masses, and R is the distance between their centers.

This equation must be modified if the center of their masses is not mainly located at the center of one of the masses, as is the case for the earth/moon and for binary star systems. To simplify the present discussion of the working hypothesis, the latter case will not be considered. However, the inclusion of these systems is straightforward and should not cause major complications in the process.

The energy of the system is given by:

$$E = \frac{GM_1M_2}{R} \qquad (8)$$

The concept of gravity is thus very useful to quantitatively model the interaction of masses. The origin of the gravitational force and its energy is has not been understood. It has been suggested that gravity is carried by particles called gravitons, but these have yet to be experimentally detected. This problem has been overcome by the discovery of photon-graviton duality. [5,9]

The Electromagnetic Force

The electromagnetic force acts between particles that have an electric charge, such as electrons and protons. Electromagnetic forces between the atoms and molecules of a solid object give the object its rigidity. The force is also responsible for the properties of magnets and for producing light. Two electric charges (positive and negative) and two magnetic extremes (north and south pole) are known. They provide for a duality of effects. The electromagnetic force is carried by photons. When elementary particles and atoms decay their energy is converted to photons.

The Strong Nuclear Force

The strong nuclear force exists within the nucleus (core) of an atom. It holds together the neutrons of the atom and the positively charged proton since protons would spontaneously separate were it not for the strong nuclear

force. The strong nuclear force is carried by particles called gluons. When the nuclear particles decay the final reaction product of the strong force are photons.

The Weak Force

The weak interaction causes the radioactive beta decay of the nucleus of an atom. These radioactive atoms are unstable because their nuclei contain too many neutrons. In the case of beta decay, a neutron changes into a proton, giving off an electron, which in this case is called a beta particle. The weak interaction is carried by W and Z particles. When nuclear particles decay, the final reaction product of the weak force are photons.

The four forces may be subdivided into two groups:

Forces of the first kind: The electromagnetic, strong and weak nuclear forces are concerned with the microscopic interaction of primary particles that make up the atomic nucleus. The electromagnetic force also provides the mechanism by which atoms interact and for the formation of molecules. The final product from the decay of these forces are photons.

Force of the second kind: Gravity concerns the macroscopic interaction of masses within an assembly of atoms and the long-range forces within the Universe. The final product of a decay of gravity is unknown.

To summarize: the forces of the first kind, the electromagnetic, the strong, and the weak forces could be combined, and the final product of their decay is photons. Gravity has thus far eluded the efforts to combine it into a generally accepted model with the other three forces, and the mechanism of its decay and its decay product(s) are not known. A model has been proposed which includes the concept of photon-graviton duality and relativistic gravity doubling. [5,9]

Mass and Energy

The four fundamental forces have their counterpart in the energies that are related to them. The above discussion of the elementary forces suggests separating the observed energy into two groups.

Free Energy, E_F is defined by the types of energy that are interconvertible with mass or bound in mass. This excludes the energy present due to gravity, E_g. Free energy is evident by its interaction with mass through the three forces of the first kind (electromagnetic, strong, and weak). They are also characterized that with the decay of the particles that carry them, photons are formed as the final energy carriers.

Mass is the dominant form of energy in the Universe. It is related by equation (1) to the free energy that is not bound in mass. This equation does not contain gravity as a factor.

Antimatter reacts with matter to form the same energy (photons) as matter by itself. Both types of matter carry the gravitational force. It must be concluded that antimatter and matter are different forms of the same free energy.

Mass was formed from free energy during the Big Bang process. Outside the laboratory, very little evidence appears to exist that mass-formation is occurring in the present Universe. Since the end of the Big Bang, a reversal is taking place where mass is converted to free energy.

It appears that it has not been possible to convert gravity to free energy or mass, although the energy types appear to be related. Gravity is always observed in combination with mass. It is assumed that gravity emerged

during the Big Bang together with mass. It has not been clear if it is a property of mass or of space, or both. The product of a decay of gravity is not known, although the existence of gravitons as the carriers of gravitational energy has been postulated; however, gravitons have not been observed experimentally.

An alternate Model for the Evolution and Destiny of the Universe

Space, gravity, mass, and free energy characterize the present state of the Universe. Two fundamental kinetic processes, expansion and mass-energy conversion also characterize it. In the present work, these two kinetic processes are proposed to be related and the question arises which of the two is dominant.

Expansion

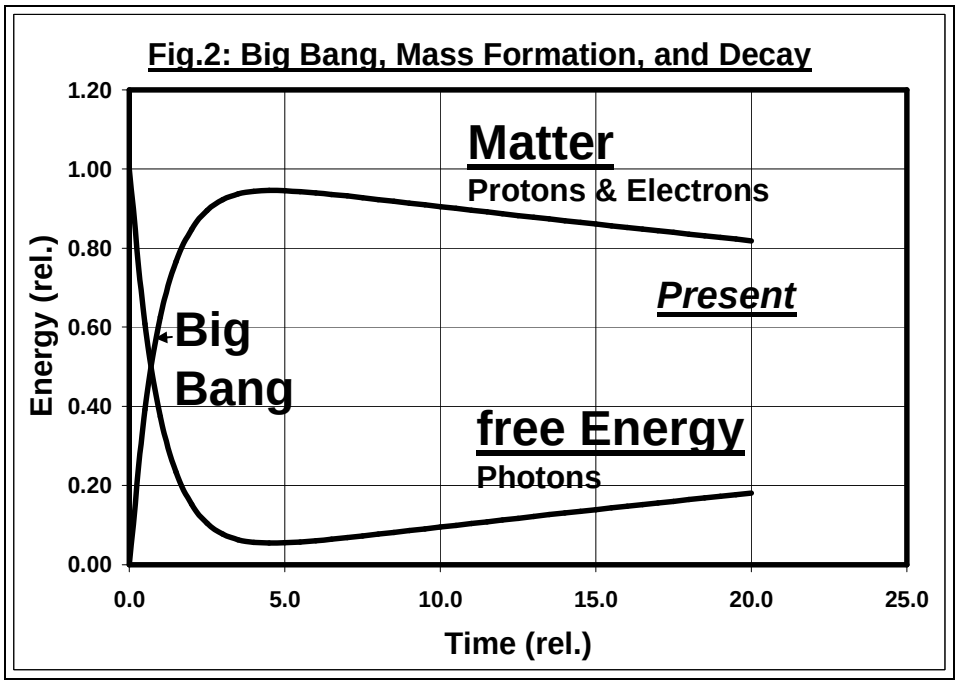
The focus of the destiny of the Universe has been centered on its expansion. The expansion model is based on astronomic observations and their interpretation. The results indicate that the relative speed of the objects is constant for most objects in the Universe. For certain objects and times of the Universe, this speed has been observed to increase. There appears no evidence that the expansion is slowing down.

It should be obvious that it is unlikely that the expansion of the Universe, a kinetic process, causes the atomic processes in the stars, and the conversion of mass to energy in this process. From the discussion above it is concluded that expansion is not the primary kinetic process in the Universe. This leaves only the alternative that the decay of mass in the Universe is the determining process that controls the expansion or compression of the Universe.

Mass-Energy Conversion

The other kinetic process in the Universe is the conversion of mass to free energy in stars and galaxies. It may be surmised that the two kinetic processes are related. However, it appears that the energy-conversion process is not being studied to the same extent as the expansion.

The working hypothesis is based on the kinetic process of mass decay that is occurring in the Universe. This kinetic change within the Universe is characterized by the transformation of mass into free energy, as observed by the burning of the stars and Einstein's equation (1). The kinetic of the formation of mass from energy, and its re-conversion to energy with time is sketched in Figure 2.



The mass to energy conversion involves only one reactant, the mass, which converts to free energy (the product). Thus, the reaction must be considered of first order or a combination of first order reactions.

	$\mathbf{M(t) = M_0 e^{-k_u t}}$	(9)

Here, M(t) is the mass of the Universe at time t from the time of its origin (t = 0), and M_0 the mass at the time of its origin. The conversion constant for the Universe, k_u, is the weighted average of the decay constants of its components. The conversion of mass in the Universe is not occurring by the same mechanism in all stars and with the same k-value. These may vary significantly from the fast decay of supernovae to the slower burning of white dwarfs. Thus, k_u is a combination of these reaction constants k_i and a weighing factor n_i which is the fraction of the total mass that is converted by the given mechanism.

	$\mathbf{\frac{1.0}{k_u} = \frac{1.0}{\Sigma n_i k_i}}$	(10)

Where

	$\mathbf{\Sigma n_1 = 1.0}$	(11)

The conversion of mass leads thus to an increase in free energy, E(t) as given by the following equation:

	$E(t) = M_0(1.0 - e^{-k_u t})c^2$	(12)

The mass-energy conversion includes the formation of new stars, which triggers further conversion of mass into free energy. The conversion of mass into free energy is a continuing process.

For the solar system, the conversion constant for the sun, k_s, was calculated from the present solar mass and the radiative mass loss.[10] The k-value (k_s = 2.100526, $*10^{-21}$ (1.0/s), or 6.62884, $*10^{-5}$ (1.0/billion (sidereal years)) of the sun may be used as an approximation in the calculations for the Universe, the galaxies, and planetary star systems, as represented by the solar system. By definition, k_s is different from k_u. Thus, the decay process of the Universe may be at a faster rate or slower rate than that of the sun. However, the k-value for the sun may provide a useful first approximation. Another complication is the observation that stars (including the sun) may go through sequentially different decay processes with different k-values. Astronomical observations can supply more accurate information for the overall decay constant of the Universe, and its possible variation throughout the life of the Universe.

According to equation 1, this conversion of mass corresponds to an equivalent formation of free energy. As discussed above, the term 'free energy', E_F, will be used for energy that is not bound in mass, but is related to the energy forms of type 1. Gravity is not considered part of E_F.

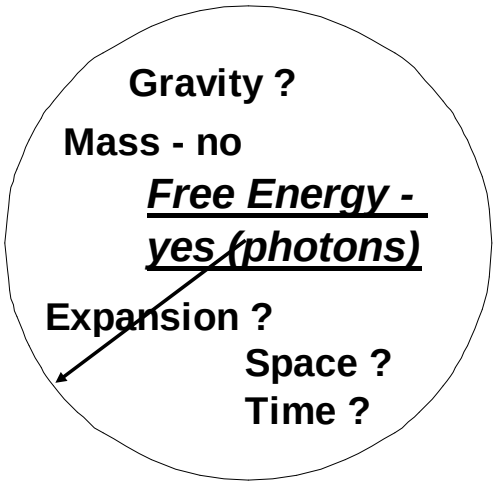
Figure 2 shows that with progressing time mass decreases and the amount of free energy in the Universe increases proportionally. The Big Bang (initial energy to mass conversion) was modeled by a first order reaction.

If the present physical process of the conversion mass to energy is extrapolated to its logical end, a state is reached which is characterized as follows:

- At the end of the Universe, there will be no mass but only free energy present, since all mass has been converted to free energy
- Since no mass is present, all free energy is in the form of photons
- Since no mass entities are present to define space, the meaning of space becomes obscure
- Since the meaning of space becomes obscure, the meaning of time becomes obscure, since a fourth dimension only makes sense if the other three dimensions (space) are meaningful.
- Since no mass is present to which gravity is tied, the meaning of gravity becomes obscure. The question arises if gravity disappears as mass disappears
- Since no mass is present, which is moving, the meaning and fate of the kinetics of expansion is obscure
- The scenarios of big crunch, inflation, and great standstill as the 'end' of the Universe become obscure
- It has been assumed that the present Universe is in a 'hot' state. The scenario of the working hypothesis indicates that in the present state, the Universe is in a relatively 'cool' state where much of the energy is bound in mass. As mass is converted and free energy is formed, the Universe moves towards a 'hot' state. This is based on the definition that more free energy is equivalent to greater 'hotness'.

This consideration of mass-to-energy conversion presents a different final state of the Universe than previously discussed scenarios. In the newly indicated final state of the Universe, all mass is converted to free energy, and the questions and concepts of expansion

Figure 3: Final State of the Universe



and contraction, gravity, space, and time become obscure. This final stage of the Universe is sketched in Figure 3.

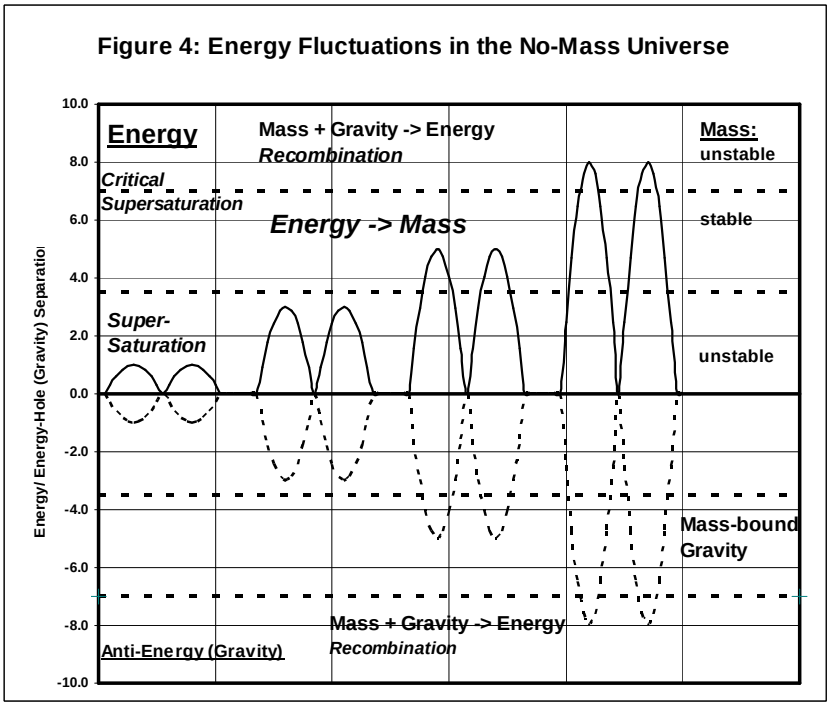
The New Big Bang Model

The evidence indicates that the Universe ends in a state of free energy and that the amount of energy is equal to that present before the beginning of the Universe. In Figure 4, the process of free energy condensation and associated free energy fluctuations is sketched.

The average energy level is indicated by the zero level. To ‘crystallize’, the energy must accumulate until the critical level for particle formation is exceeded. In crystallization science this concentration is referred to as the ‘critical supersaturation’.

These fluctuations are characterized by local increase in free energy density. Such an accumulation must be accompanied by a local ' free-energy hole' which is a deficiency of free-energy of equal energy content. To revert to the zero energy level, the energy hole must neutralize with the free-energy concentration. Thus, this energy-deficiency has the properties of anti-energy. The average energy level remains at the average zero value.

Figure 4: Energy Fluctuations in the No-Mass Universe

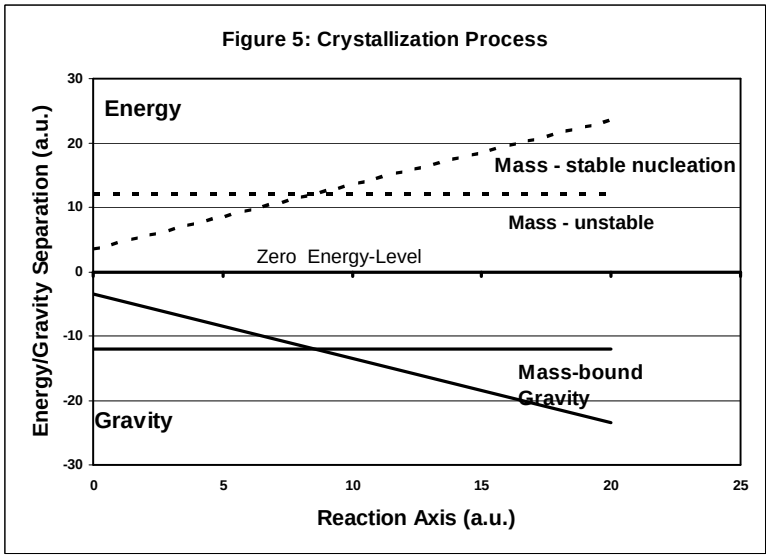


The energy fluctuations in the pre-stage will have different amplitude. Higher energy amplitudes lead to higher anti-energy amplitudes (energy-anti energy separation). The higher the separation are less likely to persist, suggesting less stability. However, the probability that very high energy-hole separations occur is not zero.

Two facts need to be introduced for further discussion. Mass has very low solubility space. Mass is a highly concentrated form of free energy. Thus, above a certain high concentration of free energy, free energy will convert to a form that is insoluble in space, i.e., into mass. This is sketched according to the balanced nucleation and growth (BNG) model in Figure 5.

For the formation of the Big Bang from free energy, a similar process is envisioned. Due to energy fluctuation, the energy concentration (or density) exceeds the critical energy concentration needed to form mass particles. At this point, mass particles will form and these mass particles will grow until the excess free energy is consumed.

The decrease of energy for conversion to mass can be modeled by a first order process:



	$\mathbf{E(t) = E_0 e^{-k_f t}}$	(13)

Moreover, mass formation by

	$M_f(t) = E_0(1.0 - e^{-k_f t})/c^2$	(14)

Here, E(t) is the energy at time t, and $M_f(t)$ is the mass formed from conversion of energy. The constant k_f is the energy-to-mass conversion constant. The over-all reaction

Figure 5: Crystallization Process
Energy
Mass - stable nucleation
Mass - unstable
Zero Energy-Level
Mass-bound
Gravity
Gravity
Energy/Gravity Separation (a.u.)
Reaction Axis (a.u.)
30
20
10
0
-10
-20
-30
0
5
10
15
20
25

which comprises mass formation (equations (9) and (12)) and the following conversion of mass to energy (equations (13) and (14)) were used to create Figure 2.

If the initially formed particles have high energy levels, they may convert to form lower energy particles. It is not known if electrons are original particles or composed of subparticles. In standard crystallizations, the initially formed unstable nuclei may contribute to the growth of more stable, mostly larger crystals by a process known as Ostwald Ripening or Gibbs -Thomson Effect.

In the case of elementary particles, it is known that Quarks and Gluons are not stable but aggregate to lower-energy combinations, which are presently observed as protons and neutrons, and further as atoms. This lowers the solubility of mass and leads to further conversion of free energy. Thus, the initial formation of mass particles from free energy leads to an avalanche of reactions and unstable particles with the conversion of free energy into stable mass particles.

Antimatter is another crystallized form of energy. The working hypothesis suggests that antimatter is formed at the same time as standard matter. It is of the same composition (free energy) as standard matter. The lack of the presence of antimatter in the Universe indicates that it is at a higher energy state than normal matter. This leads to the conversion of antimatter to standard matter under the conditions that prevail during and following the Big Bang.

It is proposed that the continuation of the energy to mass process is the Big Bang. At the end of the process, formation of new mass-entities and their growth end. No second Big Bang can occur from the same energy pool since the saturation level of free energy has been reached. After the Big Bang, a state of the Universe exists where mass and free energy are present.

Energy Accumulation – The Big Crunch

Thus far, the working hypothesis has not suggested how the free energy at the proposed end of the Universe is capable to form high concentrations to condense into mass.

A contributor to the detailed mechanism of the Big Bang is likely to be the presence of black holes. A presently unsolved question is if black holes in the Universe will decay to free energy, gather the photons due to their high gravity, or in some other way aid the re-formation of mass from free energy in the Universe. Three scenarios are considered:

- Black holes decay into free energy and the pool of their energy will contribute to the mass-less free-energy pool of the Universe. The process as initially suggested in the working hypothesis may proceed. However, the conceptual difficulty exists that the energy concentration will be low.
- Black holes grow by aggregating mass, but not photons. Due to the general decrease of gravity, the Universe will end in a set of black holes. Not enough energy will concentrate to the state original state of the Universe and of the Big Bang. Black holes and free energy will coexist. No new Big Bang is expected.
- Black holes grow by incorporating masses *and* photons. This is suggested by the observations that black holes cannot be observed by emitted or reflected light. When the decay of matter into photons decreases, the absorption of photons by black holes will exceed the formation of photons. Photons and mass will be concentrated in black holes.

When the gravity of black holes increases in this process, a process akin to the big crunch will begin. The largest black hole will eventually gather all mass, including smaller black holes, and all energy that was present at the origin of the Universe. The high concentration of energy in this black hole would provide the environment and high energy concentration for the proposed crystallization of free energy. The aggregation of the energy into mass which has less volume than the free energy would first lead to a collapse of the black hole, similar to a supernova, and then explode thus providing for a new Big Bang.

It has been shown that photons carry twice the gravity than the mass from which they originate. This translates to double the gravity per energy unit for black holes. When all mass and energy is absorbed in black holes, the Universe has twice the gravity of its initial state after mass formation. This will assure a final collapse of all energy in the Universe into a singularity.[5]

The last scenario of the working hypothesis is thus a hypothesis in which black holes become the agent for the concentration of free energy, and catalysts for the re-formation of the Universe in a stage as it presently exists.

A further question is the driving force for the aggregation of the photons. Before this question can be addressed, a few more concepts need to be developed.

Gravity – Mass Relation

What happens to the anti-energy that is associated with the free-energy density and the resulting mass?

After the nucleation of mass particles and the formation of stable elementary particles and atoms has ended, a relatively slow process begins which converts mass particles back to free energy. The driving force is the anti-energy that was created due to the association of free energy. Combination of free energy and anti-energy will reduce the energy-gravity separation created by the Big Bang.

Mass was derived from the free energy fluctuations in the pre-Universe. Thus, it must be permanently associated with anti-energy whose energy is equal to the total free energy that was bound in the mass.

	Mass (bound energy) = Anti-Energy	(15)

This process of the working hypothesis suggests that the anti-energy associated with mass is observed in the present Universe as gravity.

In the present model of the working hypothesis, conversion of all mass in the Universe to free energy was proposed to simplify discussion. Alternatively, a Big Bang may occur before all mass is converted to free energy. The energy of the Big Bang would evaporate the remaining mass entities and combine their energy with the newly formed mass into a homogeneous composition. It is expected that this material would not be detectable after the Big Bang since it is indistinguishable from the newly formed mass.

The above discussion is supported by the observation that mass to energy conversion in stars is caused by high gravity, and that gravity initiates the burning of newly formed stars. According to Einstein, gravity and acceleration are equivalent and thus in the laboratory gravity is replaced by acceleration. The necessary energy may be provided by accelerators or by high temperature.

After the Big Bang

At the stage where mass formation ends, the Universe is at the highest point of non-equilibrium. Gravity and free energy bound in mass and free energy are in a metastable state. The driving force will be the re-establishment of the free-energy state without mass (Figure 2). A comparably slow process begins where mass entities convert to free energy. This characterizes the present state of the Universe.

Consequences of the Working Hypothesis

The proposed scenario has certain consequences that must be in agreement with the present state of the Universe. These consequences are amenable to astronomic and experimental observations.

- The model is in agreement with the observations that no new mass is formed in the present Universe and only conversion of mass to free energy occurs.

- Gravity balances free energy and mass. The combined energy contained in the mass of the Universe is predicted to be equal to the energy contained in gravity.

- Gravity is always associated with mass and free energy. No free gravity exists and no mass exists without gravity.

- Where gravity exceeds a limiting value, mass will be converted to free energy. The model suggests that this loss of mass is accompanied by a loss of gravity. The conversion of mass to free energy by high gravity is exemplified in the stars and black holes.

- As the matter in the Universe decays, gravity is predicted to decrease proportionally.

- The decrease of gravity as mass is converted to energy prevents the Universe from collapsing into a big crunch. Any dark matter would participate in the mass to energy conversion process. It would be expected that it would not be available for a big-crunch.

- This predicts an increase in the expansion rate of the Universe. This eliminates the need to propose 'dark or negative energy' outside of the Universe to explain the expansion or the accelerated expansion of the Universe. This is quantitatively modeled in a separate paper.[5]

- Antimatter is a variant of stable matter. The conversion of antimatter with standard matter leads to free energy. As such, antimatter is a form of the standard free energy. Some present models of the Big Bang anticipate that an equal amount of antimatter should have formed to balance the present mass-energy. The working hypothesis changes this need since the energy, which was thought to have formed as antimatter, is present as gravity (anti-energy).

- The proposed higher energy content of antimatter vs. standard matter is amenable to experimental tests and calculations.

- Only one Big Bang occurred due to the requirement for high free-energy/gravity separation at the state of initial mass formation. This event will consume such high amounts of energy that formation of a second Big Bang out of the same energy pool must be considered highly unlikely.

- If space is a constant, the mass entities formed at the time/place of the Big Bang would be expected to spread evenly over this space.

- The concept of gravitons as the 'quantum entities' of gravity needs to be reevaluated. The separation of gravity from mass as gravitons, although possibly not impossible, would take much energy and is not highly likely. The formulation of photon-graviton duality overcomes this problem, since gravity remains associated with energy.[5]

- 'Antigravity' is present in the form of free energy and is provided by standard energy.

- The questions of standard big-crunch, inflation, and great standstill as mechanisms for the end of the Universe become mute.

- The question of lack of mass and the apparent absence of 'dark matter' in the Universe to cause a big crunch becomes mute. For accuracy in modeling the kinetic processes in the Universe, it is still necessary to account for any non-visible regular matter.

- It is suggested that the evaluation of the value and dimensional properties of the natural constants may lead to quantitative description of the pre-Universe and the Big Bang.

- Other consequences of the present model are expected to be formulated upon further examination of the working hypothesis. Experimental tests will provide modifications and support, and post questions to the presented model.

- Within the frame of the working hypothesis, the value of the natural constants is the same during all stages of the Universe. Any newly formed Universe would thus be expected to have the same physical properties as the present one, including the potential for formation of life and sentience.
- The Energy at the Pre-Big-Bang stage consists of photons which are bosons and occupy a space-less Bose-Einstein Condensate state which does not contain distinct energy states.

- After the Big Bang, the stable mass particles are electrons and protons which are Fermions, and occupy a fermion state with distinct and separate energy levels. It is presumed that the Fermion state of these particles stabilizes the present Universe.

- Photons carry twice the gravity of energy-equivalent mass. Thus, the Bose-Einstein level of photons is stabilized, since photon-photon interaction provides a fourfold gravity interaction versus energy-equivalent mass-mass gravity interaction.[9] This additional photon-photon interaction may also provide the necessary interaction for mass formation during the Big Bang. The gravity loss due to reversal of the relativistic gravity doubling may provide the energy for mass stabilization.

Conclusion

A working hypothesis for the final state of the Universe, the pre-Big Bang, and the Big Bang was derived by reviewing the present state of the Universe and its major kinetic processes, i.e., expansion and mass-energy conversion. It was concluded that of these the mass-energy conversion is the dominant kinetic process. This process provides the driving force for the observed expansion of the Universe, galaxies, and planetary systems. This process replaces the concept of negative energy. Extension of the mass-energy conversion leads to a proposed final state of the Universe where only free energy in the form of photons is present.

This final state was identified to be ambiguous about the meaning of gravity, space, expansion, and time. The consideration of the possibility that free energy would be fluctuating from the zero-point energy led to the conclusion that in this process 'free energy holes' (anti-energy) would be formed that would be permanently associated with accumulated free energy.

This free energy hole (anti-energy) was associated in the presently observed Universe with gravity, since mass (a condensed form of free energy) and gravity are similarly linked. The formation of mass from energy was suggested in analogy with crystallization phenomena where the concentration increase above a critical value leads to phase transitions.

The gathering of mass and photons in the present Universe was suggested to be achieved by black holes to achieve the necessary concentration of the total energy. The energy for mass formation at high energy

concentration is suggested from the transition of a pre-Big-Bang Bose-Einstein state of photons (spin of one) to a Fermi State of electrons and protons (spin of one-half). This transition is accompanied by a change in gravitational interaction, which provides stabilization of mass.

The working hypothesis of duality of free energy and gravity leads to the conclusion that the reversal of the mass-formation in the present stage of the Universe results in a concurring loss of gravity. This loss of gravity results in the continuing expansion of the Universe. As is shown in a related paper, this predicts an increasing rate of expansion of the Universe after a relatively stationary initial state. It provides a self-consistent mechanism for the observed spatial changes in the Universe and its components.

Considering the conservation of energy, the working hypothesis suggests that the decay of the mass to photons must result in the observed phenomenon that photons carry dualities of the observed energies, mass/gravity. It is concluded that the alignment of the dualities under high energy concentrations may provide the driving force for mass formation.

The working hypothesis suggests additional views to the existing models of the Universe, matter and energy as proposed by Einstein and quantum theory. Its suggestion of the duality of free energy and gravity (photon-graviton duality) suggests an enhanced understanding of the past, present, and future state of the Universe and its components.

Photon-graviton duality, the double gravity of photons vs. energy-equivalent mass, and the process of relativistic gravity doubling during radiative thermonuclear mass result in excess gravity vs. a pure mass-Universe. The thermonuclear conversion of mass to photons results in the necessary increase of gravity contract the Universe. This process overcomes the problem of dark matter, which does not account for the continuous thermonuclear mass loss.

The combination of the proposed processes in the working hypothesis were combined with standard gravitational equations in a separate paper. It leads to a quantitative model for the expansion of the Universe, galaxies, and planetary star systems. It also leads to quantitative models for observed changes within these systems.

	Figure Captions
Figure 1	Present State of the Universe: space, gravity, mass, free energy, expansion , and time
Figure 2	Energy to Mass (Big Bang) and Mass to Energy Conversion in the present Universe
Figure 3	The final state of the Universe
Figure 4	Energy Diagram: Pre-stage of the Big Bang, separation of energy and gravity, critical energy level for free energy above which mass forms; anti-energy = gravity
Figure 5	Balanced Nucleation and Growth Model, Nucleation Phase

Figure 1: Schematic of the Present State and Components of the Universe

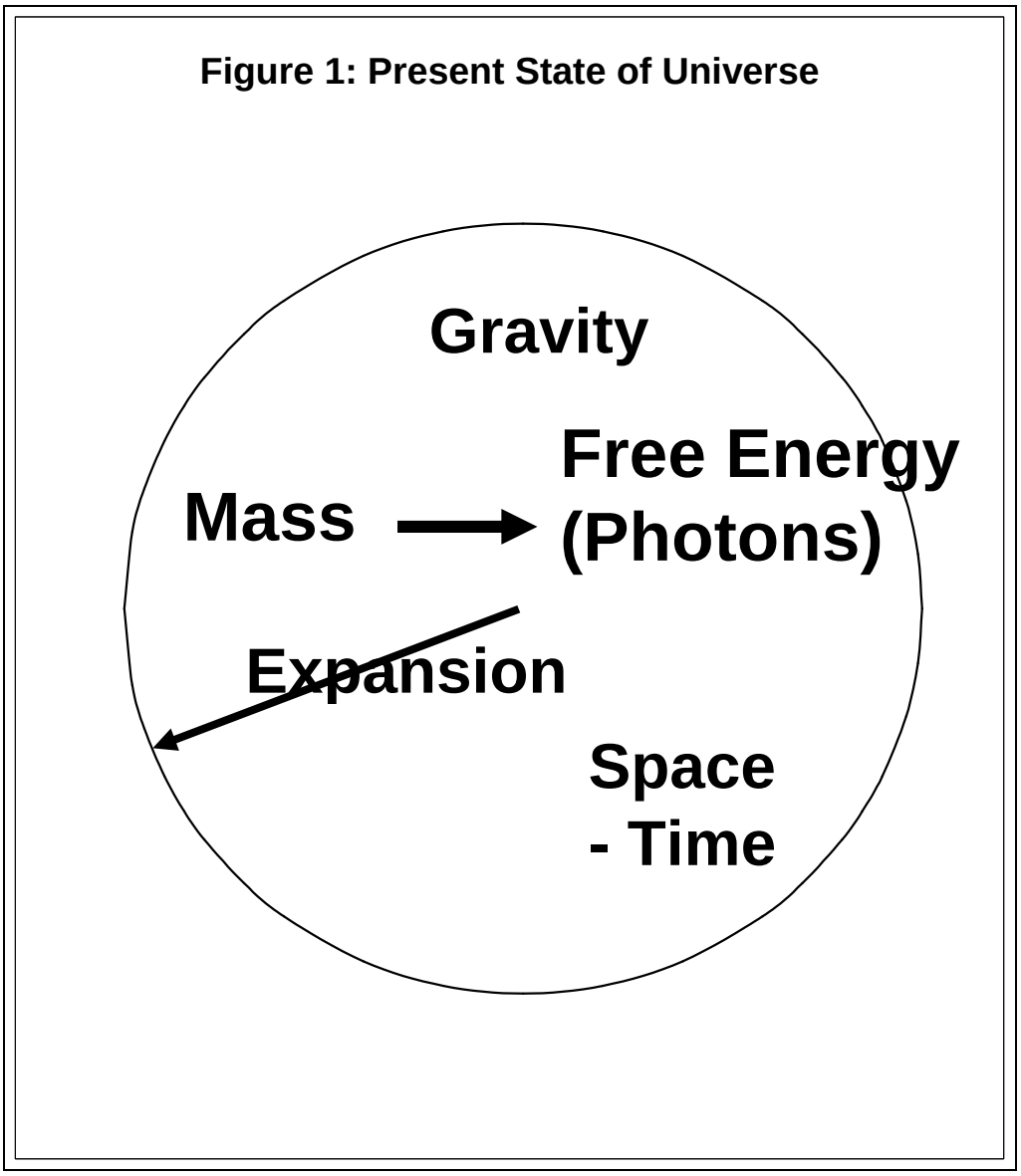


Figure 2: Formation and Decay of Matter in the Universe

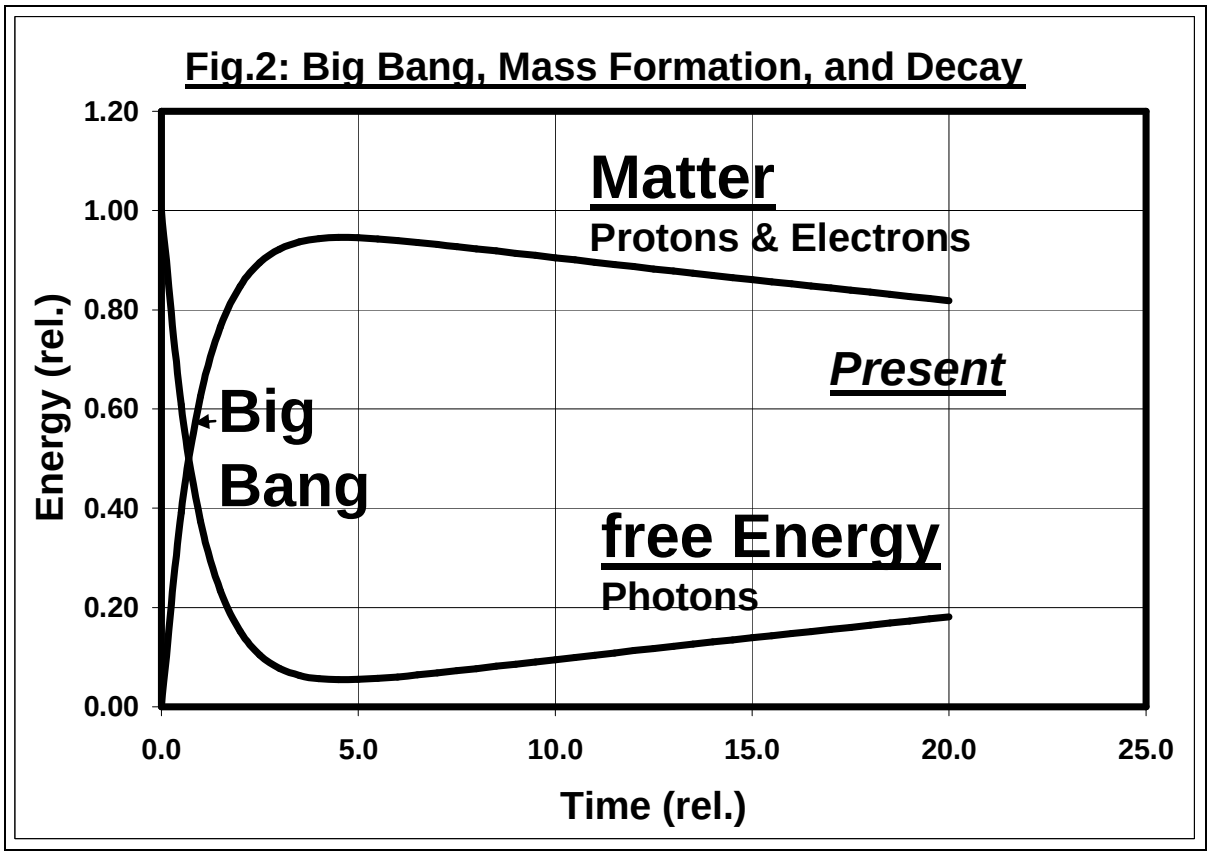


Figure 3: Schematic of the Final State and Components of the Universe

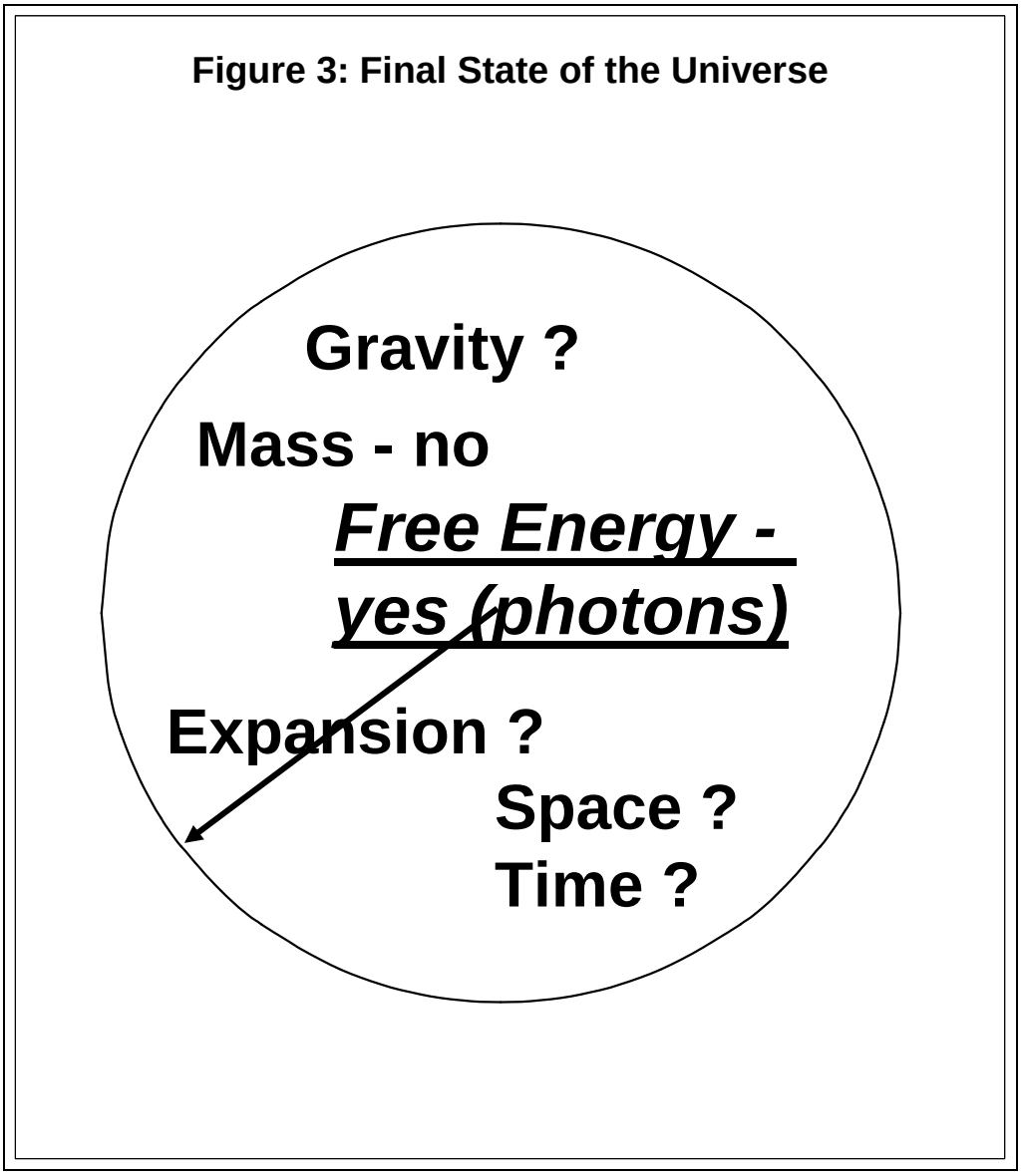


Figure 4: Schematic of Mass/Gravity Formation in no-Mass Universe

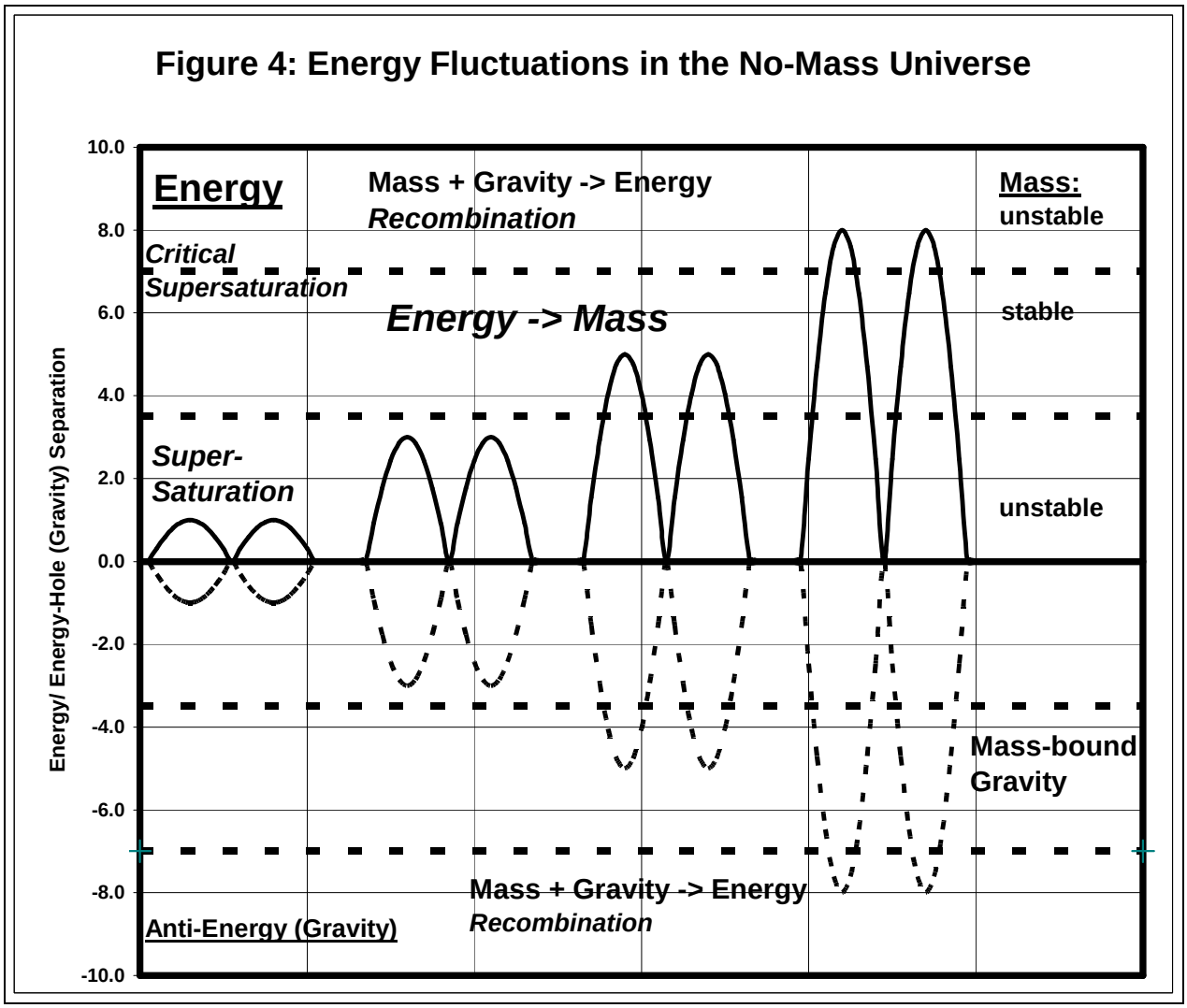
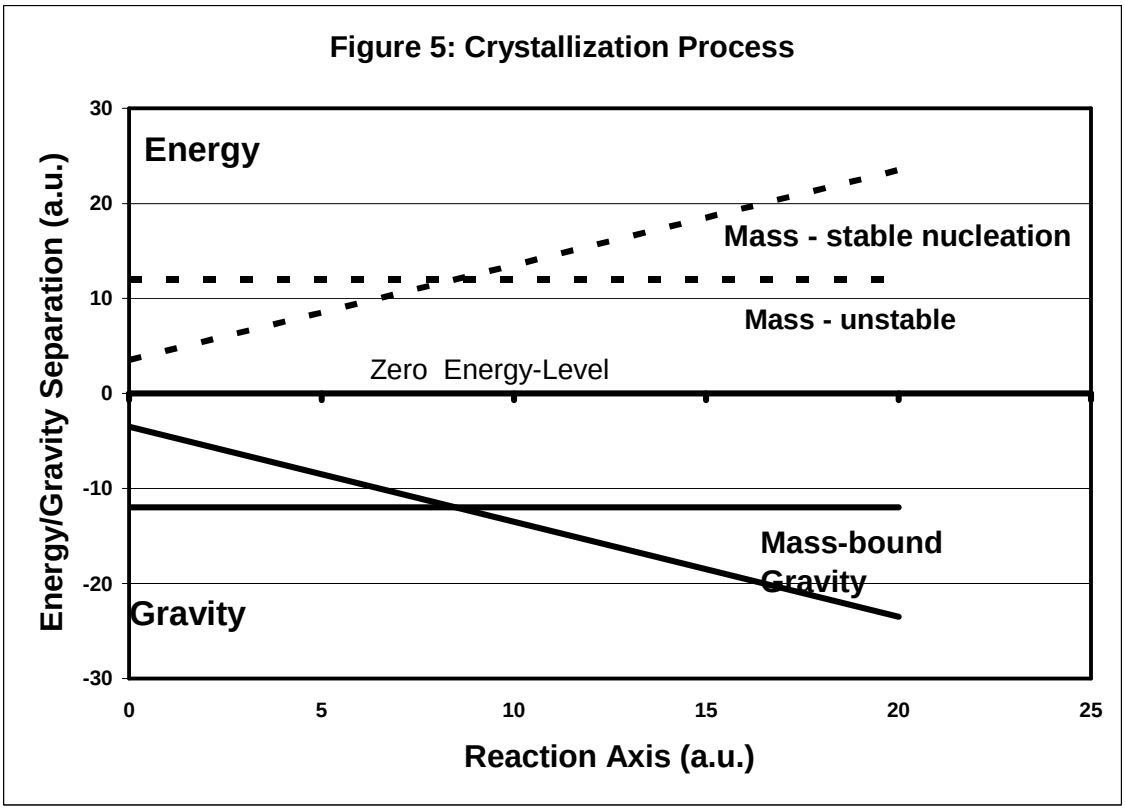


Figure 5: Schematic of Energy/Mass Equilibriums and Transitions as a Function of Energy Density



References

1 Peebles P. J. E. and t Ratra Bhara (2003), "The cosmological constant and dark energy". *Reviews of Modern Physics* **75**: 559–606

2 Permutter S., *et al.* (1999), "Measurements of Omega and Lambda from 42 high red shift supernovae", *Astrophysical J.* 517: 565–86

3 Riess, Adam G. *et al.* (1998), "Observational evidence from supernovae for an accelerating universe and a cosmological constant". *Astronomical J.* **116**: 1009–38

4 Clowe Douglas, Bradac Marusa, Gonzalez Anthony H., Markevitch Maxim, Randall Scott W., Jones Christine, Zaritsky Dennis, 'A direct empirical proof of the existence of dark matter', arXiv.org > astro-ph > astro-ph/0608407

5 Leubner, Ingo H., URL http://www.rocherresearch.us, 'The Stability of Planetary Systems' and 'Photon-Graviton Duality and Relativistic Gravity Doubling'

6 Bahcall, Neta A.; Ostriker, Jeremiah P.; Perlmutter, Saul; Steinhardt, Paul J. 'Cosmology - The cosmic triangle: Revealing the state of the Universe' , Science 284:1481-1488, 1999

7 Linde, A. 'Cosmology, A Research Briefing', National Research Council, Academic Press, Washington, D.C. 1995

8 Leubner, I. H., Current Opinions in Colloid and Interface Science 5, 151 (2000)

9 Leubner, I. H., 'Photon-Graviton Duality and Relativistic Gravity Doubling – and Alternative to Dark Matter', submitted for publication

10 Lide, David R., editor, 'Handbook of Chemistry and Physics', 85th edition, , CRC Press, Boca Raton, Fl, USA, 2004