Our Universe

In 1998 Astrophysicists had determined that our universe was accelerating and expanding, therefore will not end up in a big crunch.

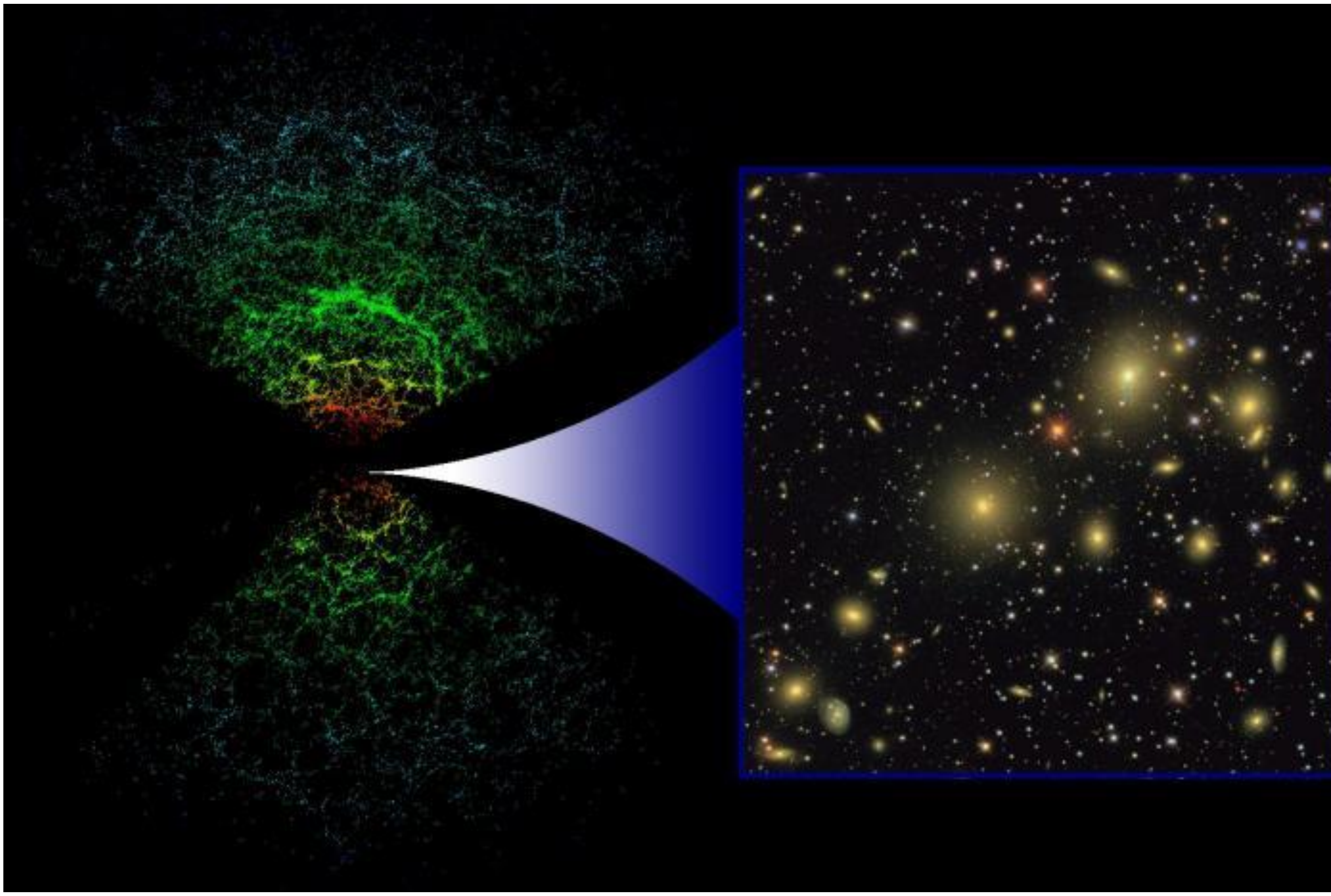
See Riess et al. 1998, AJ, 116, 1009 (submitted in March 13, 1998 and accepted in May 1998) and http://www.adsabs.harvard.edu/abs/1998AJ....116.1009R.

Now, that we have evidence to show that our universe not only expanding, but also accelerating as mention above, distances between many locations of the universe are becoming larger and larger, spreading farther away. However there are certain galaxies that are merging to form groups of galaxies, such as our milky way galaxy belongs to a group call the "Local Group". Then groups form "Clusters" in the universe. The cluster where our local group is could be near the intersection between two or three filaments or even near the intersection of a group of filaments.

At a distant our Universe seems to be made of filamentary networks of galaxies, but separating the filaments and sheets are the voids, which looks like huge bubbles walled in by these filamentary networks of galaxies. These bubbles have typical diameters of 150 million light years. Please see illustration here below on next page.

However the bubbles are expanding, as if someone is blowing bubbles in a soapy liquid. Since 1998 when astrophysicists found out that the galaxies were accelerating away from each other, there was much to be speculated what the cause is. Many people feel uncomfortable with this finding, for example: you and I are galaxies, and we feel that there is an invisible force pulling us apart. **This mysterious force is not possessed by matter or radiation but by "empty space", since we don't know what the source of energy is, it is called "Dark Energy"**. Since then different groups of scientists were working feverishly to explain this mysterious source of energy. Now there are different models, and to name a couple of models, which are Vacuum Energy and Quintessence.

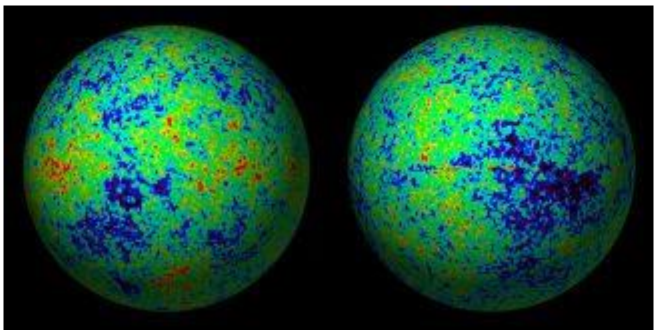
In the beginning of the 1900, Einstein was working on "General Relativity" and his theory predicts an expanding universe. He then introduced the "Cosmological Constant", which represented a hypothetical force of repulsion that could balance the force of gravity on a large scale, and allow galaxies to remain at fixed distances from one another. Somehow scientists identified this as the "Dark Energy".



The SDSS is two separate surveys in one: galaxies are identified in 2D images (right), then have their distance determined from their spectrum to create a 2 billion light years deep 3D map (left) where each galaxy is shown as a single point, the color representing the luminosity - this shows only those 66,976 of 205,443 galaxies in the map that lie near the plane of Earth's equator.

<u>In the beginning of the 1990's, Writer Rudi Tseng speculated that our universe was born from a collapsed universe, and it had gone through several bounces in the past</u>. What I mean with a "bounce" is that right after a big crunch caused by gravitational collapse, the Universe then went through a rapid expansion or inflation. Then you may ask how and why does the bounce happened? I speculate that the initial bounce was born from a super massive Black Hole which undergoes a "**<u>cosmic transition</u>**", analogous to how an aging massive star ceases to generate energy from nuclear fusion, consequently outward force ceases. Suddenly there is an imbalance of outward and inward force inside the star. When the inward gravitational force is larger, it undergoes gravitational collapse into a black hole or neutron star. It all depends on the mass of the aging star. The explosion expels most of the star's material into the surrounding of the interstellar medium.

At the moment we do not know what caused the Big Bang to occur, and what exactly happen during the inflation. **Evidence from the "cosmic microwave background radiation", points out that "inflation" did happen in our universe. Here below is the image from** WMAP**, GSFC**, NASA **microwave image.**



These microwaves are the remains of the photons, when the recombination had occurred at 380000 years after the Big Bang. I will explain to you how these remaining photons came about later on.

To get a taste of what happened during the Big Bang, you can also check out Google in the internet, there are many articles to read about the Big Bang as well as the Cosmic Microwave Background Radiation.

The "Big Bang" started with an initial condition, which scientists speculate that it could be a singularity with an enormous high density and heat. Then we can ask the question, why black holes and super massive black holes do not go through the process of inflation? Now let us examine how black holes come about, but before we do that we should do a quick review about the Big Bang and the formation of stars, because the formation of most black holes were the result of gravitational collapse of heavy objects such as stars.

According to several computer simulations suggests that the first generation stars (Population III stars) could have appeared between 100 and 250 million years after the big bang, and they might have been very bright, hot and massive, with masses of 100 to 1000 solar masses (see Scientific American December 2001, "The first stars in the Universe" written by Richard B. Larson and Volker Bromm).

Since the speed of light is 300000 km/s, our Universe could be roughly 300000 km in radius at the first second. **However I must emphasize that the Big Bang did not happen as an explosion, but rather it is the stretching of all space-time (analogous to someone blowing up a balloon or baking a loaf of bread with raisin inside, and if that someone has marked to points on the balloon, he or she will notice**

the separation of the two points getting larger as the balloon gets bigger). The concept of "space-time" is not easy to comprehend, and I will come back to this topic later on.

Therefore we should take the expansion of space-time into consideration, and it all depends on the amount of energy, density and temperature the initial condition has for the Big Bang.

Talking about Big Bang, it is in fact a cosmic transition or cosmic phase transitions from an extreme dense singularity with extreme high temperature and pressure, to what we see around us today. An analogy would be how water changes from ice to liquid and from liquid to gas in chemical phase transitions. However the time that those cosmic phase transitions took place is tremendously small within the first second, and later on in a longer time scale. Now the question is what drives the cosmic phase transitions. If we look at our previous example with water, to change from liquid water to water vapour requires heat (thermal energy). Practically all kinds of transition, such as cosmic phase transition, or chemical phase transition require energy and even biological evolution on Earth requires energy from the sun.

To explain what happen during the first second of the Big Bang? I have to borrow a few pages with illustrations from different websites, so that you can get a better picture of it. As you can see them here below.

Cosmology Primer: The Evolving Universe

time = 10^{-43} sec *size = 10^{-30} today* *temp = 10^{32} Kelvin*

The Planck era. Quantum gravity is important; current theories are inadequate. We can't get any closer to the Big Bang at *t=0* and say anything with confidence (or even with informed speculation).

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time = 10^{-35} sec *size = 10^{-26} today* *temp = 10^{28} Kelvin*

Inflation. A temporary period of domination by a form of dark energy at an ultra-high energy scale. A speculative theory, but one that has so far been consistent with observations.

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time = 10^{-12} sec *size = 10^{-15} today* *temp = 10^{15} Kelvin*

Electroweak phase transition. At high temperatures, electromagnetism is unified with the weak interactions. This is the temperature at which they become distinct.

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time = 10^{-6} sec *size = 10^{-12} today* *temp = 10^{12} Kelvin*

Quark-gluon phase transition. Quarks and gluons become bound into the protons and neutrons we see today.

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time = 10 sec *size = 10^{-9} today* *temp = 10^{9} Kelvin*

Primordial nucleosynthesis. The universe cools to a point where protons and neutrons can combine to form light atomic nuclei, primarily Helium, Deuterium, and Lithium.

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time = 3.7×10^{5} years *size = 10^{-3} today* *temp = 3×10^{3} Kelvin*

Recombination. The universe cools to a point where electrons can combine with nuclei to form atoms, and becomes transparent. Radiation in the Cosmic Microwave Background is a snapshot of this era.

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time = 10^{8} years *size = 10^{-1} today* *temp = 30 Kelvin*

The dark ages. Small ripples in the density of matter gradually assemble into stars and galaxies.

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time = 9×10^{9} years *size = 5×10^{-1} today* *temp = 6 Kelvin*

Sun and Earth form. From the existence of heavy elements in the Solar System, we know that the Sun is a second-generation star, formed about five billion years ago.

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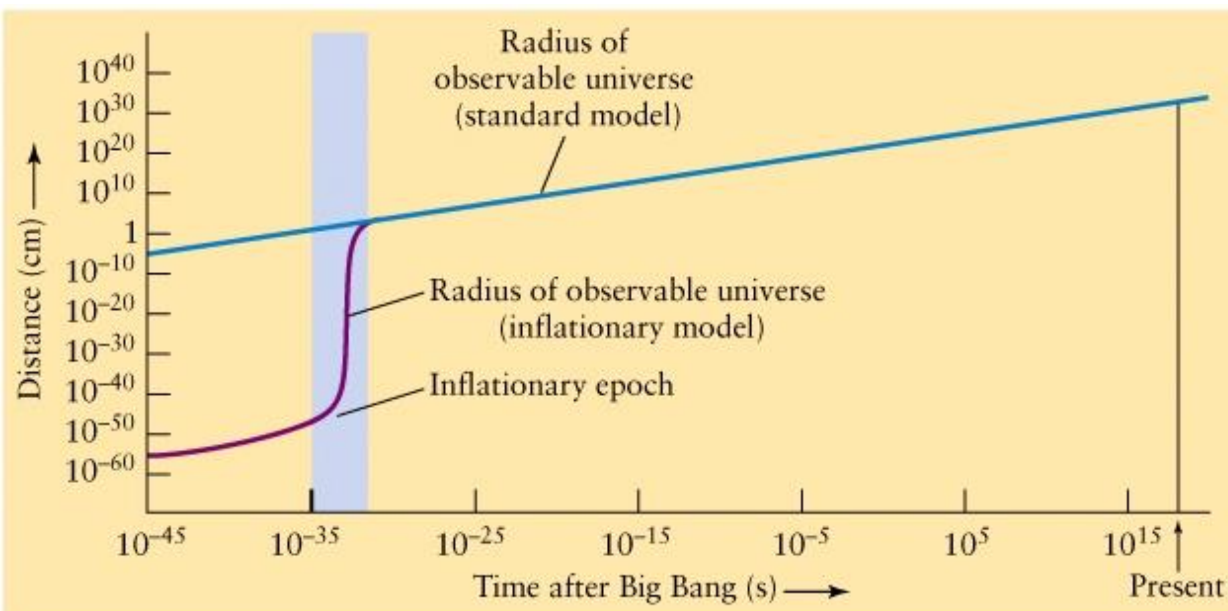
time = 13.7×10^{9} years *size = 10^{0} today* *temp = 2.74 Kelvin*

Today.

Inflation

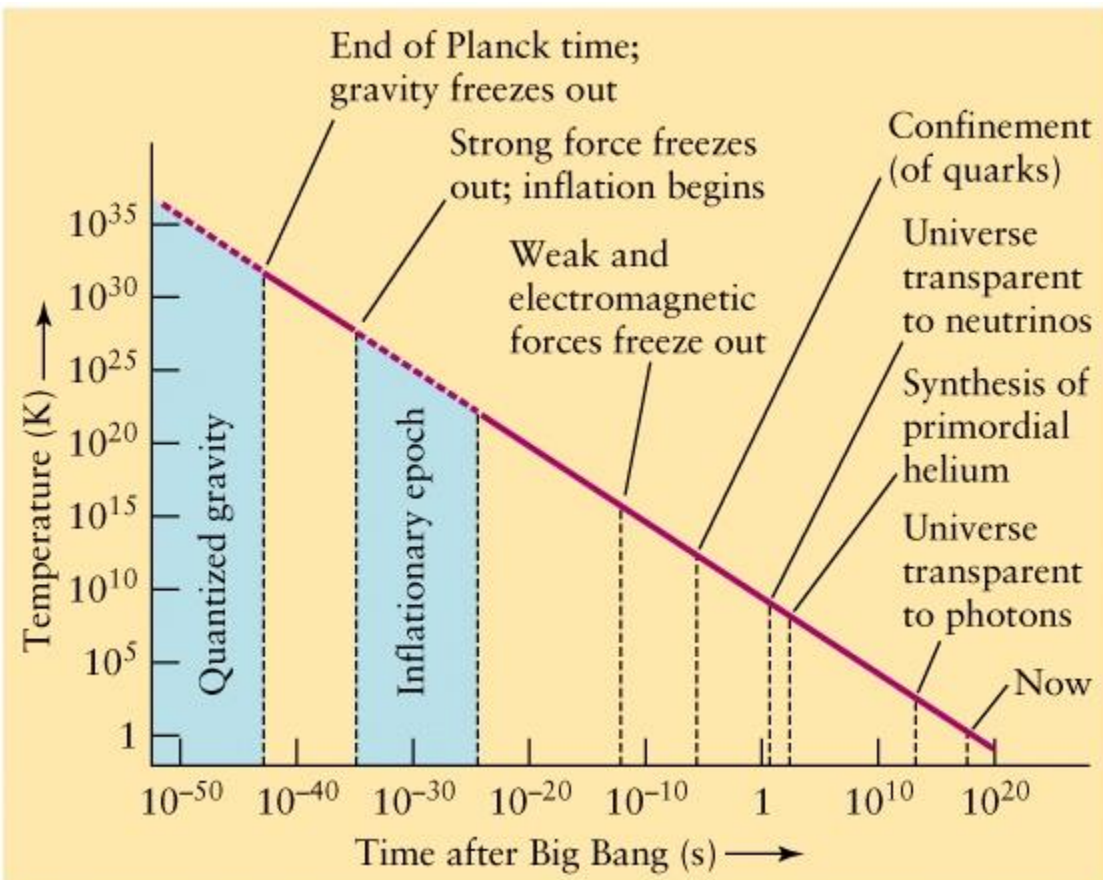
- The theory of inflation was proposed to solve these problems.
- Around 10^{-34} s after t=0, a region of size
  $r = c\,t = 3 \times 10^{-26}$ m
  is in causal contact and can be at the same temperature.
- The theory of inflation proposes that at this time a period of exponential expansion occurs lasting until $t = 10^{-32}$ s.
- During this time the universe increases in size by a factor of e^{100}.
- This causes the region of size 3×10^{-26} m to expand to the size 9×10^{17}m.
- This larger region can all be at the same temperature and evolve into the universe which we observe.
- The rapid change in size also has the effect of making the curvature very close to zero.



The Initial Singularity

- When the Universe was very young, the distances between things were very tiny.

- Quantum mechanics is needed to describe very tiny distances.
- For instance Heisenberg's uncertainty relation should apply here.
- The equations describing cosmology come out of the theory of general relativity which does not include quantum mechanics.
- The equations of general relativity are only valid when describing distances larger than 10^{-35}m.
- Or equivalently, general relativity only describes the universe when it is older than 10^{-44} s.
- In order to describe the earliest times, a theory which combines gravity and quantum mechanics is needed (called quantum gravity).
- One theory which might work is called Superstring Theory.
- Superstring theory predicts that the universe is actually 10 dimensional, but that we only directly experience 3 dimensions.
- Superstring theory may be able to describe the earliest times properly.
- This is still unknown territory!



<u>As you can see there are different cosmic phase transitions during the first second of the Big Bang. Interestingly all forces such as gravitational, strong forces, weak, electromagnetic forces and all the</u>

particles such as quarks, neutrinos, baryons, and photons, require huge amounts of energy for them to be created.

For example to create strong forces (also called nuclear force), temperature of 10^28 K is required, and it freezes out at 10^-35 s after the Big Bang (see illustration here above). Strong force is mediated by gluons and they act upon quarks, anti-quarks and gluons themselves. For weak and electromagnetic forces to be created, temperature of 10^17 K is required, and it freezes out at 10^-13 s after Big Bang, and weak force is mediated by these bosons W^+, W^- and Z^0. See the diagram here below.

Besides in our daily lives we experience how electromagnetic waves are generated by accelerating electrons, such as in electric motors and radio transmitting station. Electromagnetic waves can be converted back into sound waves in a radio receiver, and photons from the sun are electromagnetic waves which can be converted back into direct current electricity using photovoltaic cells (solar cells). Then this direct current electricity can be used to generate electromagnetic force to turn an electric motor.

Interaction	Gravitational	Weak	Electromagnetic	Strong	
		Electroweak		Fundamental	Residual
Acts on:	Mass-Energy	Flavor charge	Electric charge	Color charge	See info.
Particles Experiencing it:	All	Leptons Quarks	Electrically-charged	Quarks Gluons	Hadrons
Particles Carrying it:	Graviton (not yet observed)	$W^+ W^- Z^0$	γ	Gluons	Mesons
Strength for: 2 quarks at 10^{-18} m	10^{-41}	0.8	1	25	Not applicable to quarks
2 quarks at 3×10^{-17} m (relative to e/m)	10^{-41}	10^{-4}	1	60	
2 protons in nucleus at 10^{-14} m	10^{-36}	10^{-7}	1	Not applicable to hadrons	20

General Relativity can still describe the Cosmic Phase Transitions up to 10^-44 second, as you can see here below.

The Planck Epoch: 0 < t ≤ 10^-43s (> 10^40 K)

The Planck epoch is the earliest period of time in the history of the Universe, spanning the brief time immediately following the Big Bang during which the quantum effects of gravity were significant.

Characteristic: quantum gravity

Grand Unification Epoch: 10^-43s ≤ t ≤ 10^-36s (10^40 K – 10^36 K)

Assuming the existence of a Grand Unification Theory (GUT), the Grand Unification Epoch was the period in the evolution of the early Universe following the Planck epoch, in which the temperature of the Universe was comparable to the characteristic temperatures of GUTs. If the grand unification energy is taken to be 10^15 GeV, this corresponds to temperatures higher than 10^27 K. During this period, three of the four fundamental interactions — electromagnetism, the strong interaction, and the weak interaction — were unified as the electronuclear force. Gravity had separated from the electronuclear force at the end of the Planck era. During the Grand Unification Epoch, physical characteristics such as mass, charge, flavor and color charge were meaningless. The Grand Unification Epoch ended at approximately 10^-36s after the Big Bang. At this point, the strong force separated from the other fundamental forces.

Characteristics: gravity freezes out, the "grand unified force (GUT)"

Inflationary Epoch: 10^-36s ≤ t ≤ 10^-32s (10^36 K – 10^33 K)

The Inflationary Epoch was the period in the evolution of the early Universe when, according to inflation theory, the Universe underwent an extremely rapid exponential expansion. This rapid expansion increased the linear dimensions of the early Universe by a factor of at least 10^26 (and possibly a much larger factor), and so increased its volume by a factor of at least 10^78. At this time, the strong force started to separate from the electroweak interaction. The expansion is thought to have been triggered by the phase transition that marked the end of the preceding Grand Unification Epoch at approximately 10^-36s after the Big Bang. One of the theoretical products of this phase transition was a scalar field called the inflation field. As this field settled into its lowest energy state throughout the Universe, it generated a repulsive force that led to a rapid expansion of the fabric of space-time. This expansion explains various properties of the current Universe that are difficult to account for without the Inflationary Epoch (flat Universe, horizon problem, magnetic monopoles). The rapid expansion of space-time meant that elementary particles remaining from the Grand Unification Epoch were now distributed very thinly across the Universe.

However, the huge potential energy of the inflation field was released at the end of the Inflationary Epoch, repopulating the universe with a dense, hot mixture of quarks, anti-quarks and gluons as it entered the Electroweak Epoch.

Characteristics: inflation begins, strong force freezes out

Electroweak Epoch: 10^-32s ≤ t ≤ 10^-12s (10^33 K – 10^20 K)

The Electroweak Epoch was the period in the evolution of the early Universe when the temperature of the Universe was high enough to merge electromagnetism and the weak interaction into a single electroweak interaction. At approximately 10^-32s after the Big Bang the potential energy of the inflation field that had driven the inflation of the Universe during the Inflationary Epoch was released, filling the Universe with a dense, hot quark-gluon plasma (reheating). Particle interactions in this phase were energetic enough to create large numbers of exotic particles, including W and Z bosons and Higgs bosons. As the Universe expanded and cooled, interactions became less energetic and when the Universe was about 10^-12s old, W and Z bosons ceased to be created. The remaining W and Z bosons decayed quickly, and the weak interaction became a short-range force in the following Quark Epoch. After the Inflationary Epoch, the physics of the Electroweak Epoch is less speculative and better understood than for previous periods of the early Universe. The existence of W and Z bosons has been demonstrated, and other predictions of electroweak theory have been experimentally verified.

Characteristics: weak force freezes out, 4 distinct forces (EM dominates)

Quark Epoch: 10^-12s ≤ t ≤ 10^-6s (10^20 K – 10^16 K)

The Quark Epoch was the period in the evolution of the early Universe when the fundamental interactions of gravitation, electromagnetism, the strong interaction and the weak interaction had taken their present forms, but the temperature of the Universe was still too high to allow quarks to bind together to form hadrons. The Quark Epoch began approximately 10^-12s after the Big Bang, when the preceding Electroweak Epoch ended as the electroweak interaction separated into the weak interaction and electromagnetism. During the Quark Epoch the Universe was filled with dense hot quark-gluon plasma, containing quarks, gluons and leptons. Collisions between particles were too energetic to allow quarks to combine into mesons or baryons. The Quark Epoch ended when the Universe was about 10^-6s old, when the average energy of particle interactions had fallen below the binding energy of hadrons. The following period, when quarks became confined within hadrons, is known as the Hadron Epoch.

Characteristics: Universe contains hot quark-gluon plasma: quarks, anti-quarks, gluons and leptons; quarks and anti-quarks annihilate

The Universe had expanded to about the size of 10^12cm (10^7km), about 7 times the size of the Sun at 10^-12s.

Hadron Epoch: 10^-6s ≤ t_≤ 1 s (10^16 K – 10^12 K)

The Hadron Epoch was the period in the evolution of the early Universe during which the mass of the Universe was dominated by hadrons. It started approximately 10^-6s after the Big Bang, when the temperature of the Universe had fallen sufficiently to allow the quarks from the preceding Quark Epoch to bind together into hadrons. Initially, the temperature was high enough to allow the creation of hadron/anti-hadron pairs, which kept matter and anti-matter in thermal equilibrium. However, as the temperature of the Universe continued to fall, hadron/anti-hadron pairs were no longer produced. Most of the hadrons and anti-hadrons were then eliminated in annihilation reactions, leaving a small residue of hadrons. During the annihilation, gamma rays were produced, and the elimination of anti-hadrons was completed by one second after the Big Bang, when the following Lepton Epoch began.

Characteristics: quarks and gluons bind into hadrons; baryogenesis; baryons and anti-baryons annihilate

The Universe had expanded to about the size of 10^17cm (10^12km), about 7X10^5 times the size of the Sun at 10^-6s

Lepton Epoch: 1 s ≤ t ≤ 3 min (10^12 K – 10^10 K)

The Lepton Epoch is the period when the Universe had expanded and cooled sufficiently for particles such as gamma rays to produce electron/positron pair, according to the "equivalence of energy and matter (E = mc^2)", which is energy can be converted to matter, and matter can be converted back to energy.

• Muon pair production and annihilation:

At sufficiently high temperatures, there is a pair production:

$\Gamma + \Gamma \rightarrow \mu^+ + \mu^-$,

==> photon energy —> muon mass.

This can persist only as long as $kT \sim 2m_\mu c^2$:

$T \geq (2m_\mu c^2) / k = 2(200m_e)c^2 / k$

$= [2(2009.1 \times 10^{-28})(3 \times 10^{10})^2] / (1.38 \times 10^{-16}) = 2 \times 10^{12}$ K.

Therefore, muons annihilate at $T \sim 10^{12}$ K (100 MeV).

• Electron/positron pair production and annihilation:

The argument used for muon annihilation applies to electron-positron annihilation

$T \geq 2m_e c^2 / k = 10^{10}$ K,

so, electrons and positrons annihilate at $T \sim 10^{10}$ K (1 MeV).

Characteristics: Universe contains photons (Γ), muons ($\mu^\pm$), electrons/positrons ($e^\pm$), and neutrinos; nucleons n and p in equal numbers

Annihilation Epoch: t =1 s ($T \leq 10^{12}$ K ~ 10^8 MeV)

Characteristics: μ^+ and μ^- annihilate (produce 2 gamma rays, each 50 MeV); neutrinos decouple; $e^\pm$, gamma rays (Γ) and nucleons remain.

Reactions: $e^+ + n \Leftrightarrow p + V_e$

$e^- + p \Leftrightarrow n + V_e$

$n \rightarrow p + e^- + V_e$

The Universe had expanded to about the size of 10^{20}cm (10^{15}km), about 7×10^8 times the size of the Sun at 1s.

Annihilation Epoch: t =100 s ($T \leq 10^{10}$ K ~ 1 MeV)

As the Universe expanded and continued to grow larger, the temperature had sufficiently cooled down below 10^{10} K. The gamma ray photons were stretched by the growing Universe and they had lost their energy below the level which would allow them to be converted to electrons and positrons, as a result the population of electrons and positrons were diminishing due to the annihilation of electrons and positrons into gamma rays.

Characteristics: e+ and e− annihilate (produce 2 gamma rays, each 500 KeV); gamma rays (Γ) and nucleons (protons, neutrons, etc.) remain.

The Universe had expanded to about the size of 10^21cm (10^16km), about 7X10^9 times the size of the Sun at 100s.

Big Bang Nucleosynthesis Epoch: 100s ≤ t ≤ 1000s (10^10K - 10^9K)

Just about 3 minutes before the Big Bang, when the energy density of the early Universe was still high, protons and neutrons were continuously colliding to each other, but they couldn't stick together to form Deuterium nuclei, because their energies were still too high, and when the temperature was higher than 10^10 K, where photons have energy higher than E=(M-n + M-p - M-D)c^2 will break the nucleus of Deuterium (n + p) into its constituents particles (photo-dissociation). This prevented further nuclear reactions to form heavier nuclei. This type of situation where an intermediate product is the weak link in the overall synthesis is sometimes called a "bottleneck". Once the **Deuterium bottleneck** is overcome, the remaining reactions leading to heavier elements are able to be completed.

There are two ways that the newly formed deuterium nuclei could form Helium.

Pathway 1

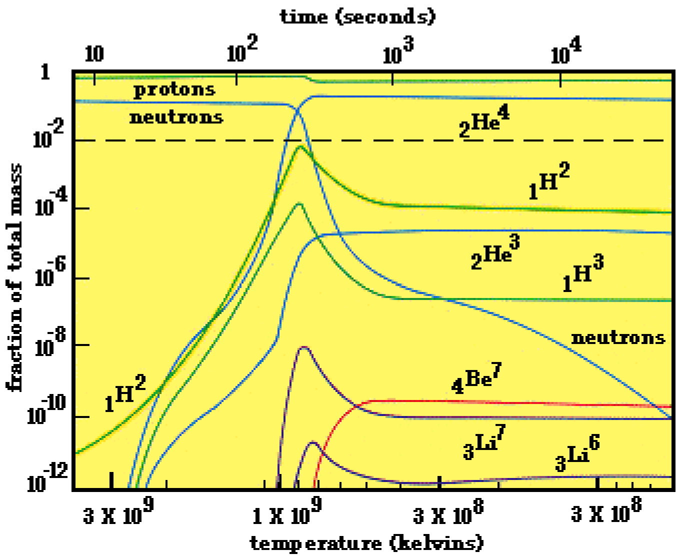
The Deuterium nucleus (n+p) collides with a proton (p) to form He-3 (n+p+p), then with a neutron (n) to form He-4 (n+n+p+p).

Pathway 2

The Deuterium nucleus (n+p) collides with a neutron (n) to form H-3 (Tritium, n+n+p), then with a proton (p) to form He-4 (n+n+p+p).

When nucleosysnthesis was completed about 20 minutes after the Big Bang, the Universe consisted of 25% of Helium nuclei and 75% of Hydrogen nuclei (by mass).

Below is a graphical summation of nucleosynthesis in the early universe. The graph shows the relative abundances of different nuclei (vertical axis) during the first three hours of creation. The horizontal axis has been labeled using both time (top) and the equivalent temperature (bottom). For those not used to using a logarithmic scale, a dashed line has been added at the 1% abundance level. Anything below this line would be less than 1% of the total mass present.



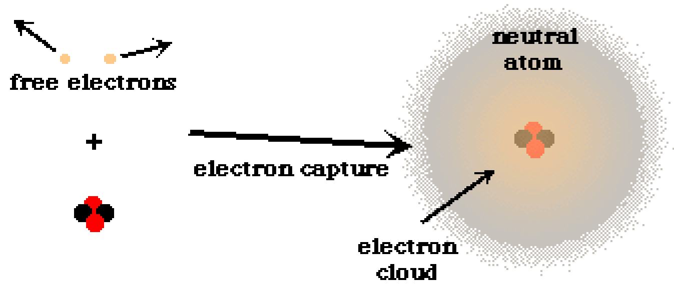
As can be seen from the curves, at the higher temperatures only neutrons and protons exist, with there being more protons than neutrons. But, as the temperature decreases, there is an increase in the amount of Deuterium and Helium nuclei. Just below 10^9 K there is a significant increase in Deuterium and Helium, and a decrease in the abundance of protons and neutrons. This is the Deuterium bottleneck mentioned previously. This uses up all the free neutrons and some protons, and causes the neutron line to drop off, and the proton line to dip (relatively few protons are used up). The Deuterium abundance only increases to a point, because it is an intermediate to the formation of Helium. So as it is created, it is quickly consumed to complete the process of Helium nucleosynthesis. Once all the neutrons have been used up, its presence drops off. At the end of the Big Bang Nucleosynthesis around 20 minutes after the Big Bang, a small amount of Lithium and Beryllium were also synthesized, thereafter the Universe was too cool for nuclear fusion to occur.

Characteristics: gamma rays, protons, nuclei of Helium, Hydrogen, Deuterium, Lithium and Beryllium remain.

The Universe had expanded to about the size of 10^22cm (10^17km), about 7X10^10 times the size of the Sun at 1000s.

Electron Capture/Recombination Epoch (20 min ≤ t ≤ 380000 years) (10^9 K – 3×10^3 K)

The final step in the formation of elements was the capture of the proper number of free electrons to form neutral atoms.



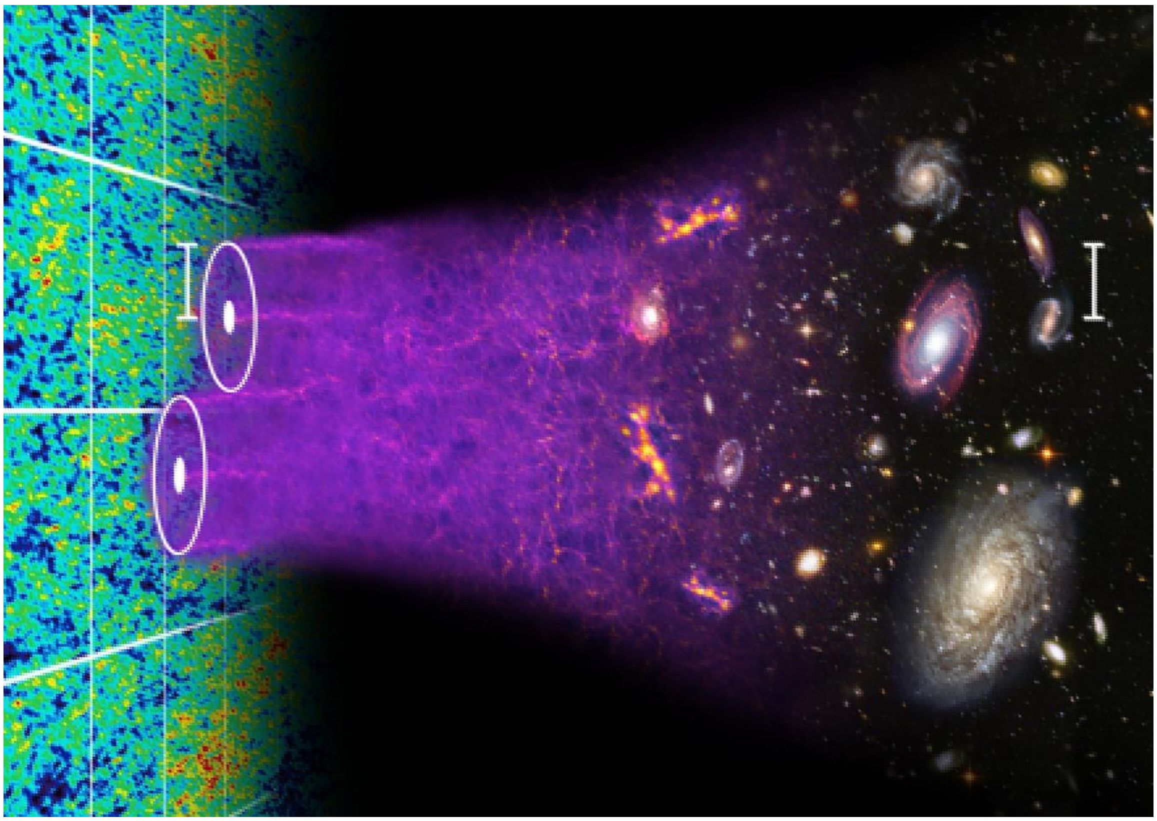
About 20 minutes into the expansion of the Universe, it had grown to about 10^17 km in diameter, which is about 10582 light years across (our milky way galaxy is 30000 light years across). The temperature was about 10^9 K and slowly decreasing due to the expansion of space-time.

These charged ionized nuclei and negatively charged electrons were moving at a great speed, constantly colliding to each other, and accelerating away from each other, where photons were created. From physics we learn that electromagnetic radiation is created by accelerating moving charged particle. Besides moving charged particles also generate a magnetic field around themselves. When a negatively charged electron collides with a positively charged hydrogen nucleus, they form a neutral atom momentarily, then after a very short time it becomes ionized by a charged particle, while they do so, they emit a photon. At the same time photons were scattered by Thomson scattering, this is analogous to a bouncing ball representing a photon and the walls in a room are the charged particles such as electrons and ionized nuclei, eventually the ball cannot get out of the room. Therefore the Universe was opaque to light at that time, not until the process of "**recombination**" occurred. **In fact the "recombination" should be called "combination" because this was the first time when electrons combine with ionized positively charged nuclei to form neutral atoms. That is when the temperature slowly decreases to about a few thousand degree Kelvin. Then ionized nuclei were able to combine with electrons to form neutral atoms such as hydrogen and helium around 379000 years after the Big Bang**.

When the process of recombination was completed around 380000 years after Big Bang, there were no charged particles for Thompson scattering, so the remaining photons travelled unimpeded through space. **Because our Universe had expanded and continued to grow larger, these remaining photons (relic radiation) have been stretched or**

redshifted, and now they are being detected as microwaves, and the spectrum of this microwaves peaks at the frequency of 160.2 GHz, corresponding to a wavelength of 1.9 mm, with a black body temperature of 2.725 K (Our body has a black body temperature of 310 K / 37° C and it peaks at the spectrum of 8 μm and the Sun has a black body temperature of 6000 K and it peaks at the spectrum of 500 nm, which is green light).

The illustration here below is an artist concept of the history of our Universe.



First Generation Star formation

Please look at "The formation of the first star in the Universe" by Abel et al. 2002, and http://www.solstation.com/x-objects/first.htm.

According to the Cosmological models from the authors who wrote this article in Scientific American December 2001, "The first stars in the Universe" written by Richard B. Larson and Volker Bromm), suggest that although in the early universe was remarkably smooth, the cosmic microwave background radiation shows evidence of small-scale density fluctuations, clumps in the primordial soup. The Cosmological models predict that these clumps would gradually evolve into gravitationally bound structures. Smaller systems would form first and then merge into larger agglomerations. The denser regions would take the form of a network of filaments, and the first star forming systems, small proto-galaxies would coalesce at the nodes of this network. In a similar way, proto-galaxies would then merge to form galaxies, and the galaxies would congregate into galaxy clusters.

Their models also suggests that the first generation stars (Population III stars) could have appeared between 100 and 250 million years after the big bang, and they might have been very bright, hot and massive, with masses of 100 to 1000 solar masses. The first generation stars had surface temperature of about 100000 Kelvins, about 17 times higher than the surface temperature of the Sun. Therefore, the first starlight in the Universe would have been mainly ultraviolet radiation, and it would have begun to heat and ionize the neutral Hydrogen and Helium gas around these stars soon after they formed, and a growing bubble of ionized gas would have formed around each one. As more and more stars formed over hundreds of millions of years, the bubbles of ionized gas would have eventually merged, and the intergalactic gas would have completely ionized. According to their study even a small fraction as small as one part in 100000 of the gas in the Universe could have been enough for these stars to ionize much of the remaining gas. <u>Recently scientists from the California Institute of Technology and the Sloan Digital Sky Survey have found evidence of the final stages of this ionization process</u>.

Most of these first generation stars would have had relatively short lifetimes, only a few million years, and most of them would have masses between 100 to 250 solar masses, and it was predicted that they would blow up completely in energetic explosions. Those first stars which are larger than 250 solar masses would then collapse into Black Holes.

There are stellar Black Holes with radius of 30 km or bigger, and with masses of 10 solar masses or more. On the other hand super-massive Black Holes range from 0.001 to 10 AU (1 AU is about 150 million km), have masses about hundreds of thousands to billions of solar masses. Evidence suggest that when Black Holes collide, they merge and becoming bigger and more massive.

<u>Therefore I would speculate that there is a limit, similar to the "Chandrasekhar Limit" or the "Tolman-Oppenheimer-Volkoff limit"</u>.

The Chandrasekhar Limit describes a limit that a star can reach at the end of its life span, when it has gone through the process of nuclear fusion, producing heavier elements from lighter ones, such as from hydrogen to helium, than from helium to carbon, nitrogen, oxygen and iron. Through billions of years, a main sequence star **(most stars are main sequence**

star) then builds up a central core in which heat inside the core is insufficient to produce nuclear fusion. Scientists call this state of matter "degenerate". Degeneracy is a state of matter attained when atomic particles are packed together as tightly as possible, at densities of several thousand of tonnes per cubic meter as in electron degenerate matter. Particles which are very closely together are forbidden by the Pauli Exclusion Principle to have the same energy, and as a result, the particles repel each other, generating the "degeneracy pressure" at the core of the star to support against its gravitational inward force. In a White Dwarf it is the "electron degeneracy pressure", and in Neutron star it is the "neutron degeneracy pressure". **The maximum mass that a star can have and still become a White Dwarf is 1.4 solar masses (M-Sun), and it is called the "Chandrasekhar limit", and the "Tolman-Oppenheimer-Volkoff limit" for Neutron Star is 3 solar masses**.

For a main sequence star that is smaller than 8 solar masses, the mass of the central core will be smaller than the Chandrasekhar limit. It then continues to lose mass until only the core remains, which then becomes a "White Dwarf". However when a main sequence star which is larger than 8 solar masses, it then collapse into a neutron star or a black hole.

As the Universe continues to expand and accelerating to the far future, our Milky Way Galaxy and many other galaxies will be swallow up by an enormous ultra-super massive Black Hole, and so do other ultra-super clusters forming their Black Holes. These Black Holes are the seeds of future Universes. But it all depends on the amount of mass they acquire, analogous to what a star becomes when it reaches the end of its lifespan. Is it going to be a White Dwarf, Neutron Star or a Black Hole? It all depends on the mass of the star.

At the beginning when I started to write about our Universe, I speculate that our Universe was born from a collapsed Universe, Hypothetically our Universe could had been born from a seed as mention above. How is it possible for an ultra super-massive Black Hole to go through an initial Cosmic Phase Transition, then gaining more mass afterward as the embryonic Universe going through several bounces.

Writer speculates that during each bounce mass are created. Where does the mass come from? According to General Relativity energy E = mc^2. Energy can be converted to matter, and matter can be converted back to energy. As I had mentioned earlier during the Hadron Epoch and the Lepton Epoch about 10^-6 s to 3 minutes after the Big Bang, when the temperature was about 10^16 K to 10^10 K, which corresponds to about 10^6 MeV to 1 MeV, gamma rays were converted to matter, and matter were converted back to gamma rays. We can also see when uranium undergoes fission in a nuclear power plant, plutonium and energy is produced.

From physics we learn that an object high above on top of a building has gravitational potential energy, and when this object falls to the ground, gravitational potential energy is converted into kinetic energy. Therefore the taller the building, the bigger the gravitational potential energy an object can have. The same principle will be applied to the bouncing Universe. Right after the Big Bang there were different cosmic phase transitions. For example, during the Inflationary Epoch, the Universe expanded exponentially, its volume increase by a factor of 10^78. During the Quark Epoch, quarks and anti-quarks annihilate, when they annihilate, energy and radiation is released. Energetic particles and radiation then pushes particles farther away, and causes the universe to grow bigger. Annihilation of matter and anti-matter also occurred during the Hadron and Lepton Epoch creating more space-time for the Universe. Since first generation stars had masses between 100 to 250 solar masses, and they would completely obliterate themselves in energetic supernova, pushes matter and gases even farther away, creating an even larger Universe, as if someone bringing an object even higher in a building, acquiring an even larger gravitational potential energy for that object. Can you imagine what happen when someone throw an old television set out the window from the first floor, the TV tube might be damage upon impact on the ground. Now guess what happen when someone throws an old TV out the window from the twenty fifth floor or even higher of a building. Upon impact on the ground, the old TV will shatter into many pieces and electronic parts will be flying apart into different direction. Please don't do this from your appartment or from any appartment building, unless you are absolutely sure that there is no one on the ground.

Here below are the formulas for kinetic and gravitational potential energy.

$E_g = m \times g \times h$, where m is mass, g is Earth's gravity, and h is the height.

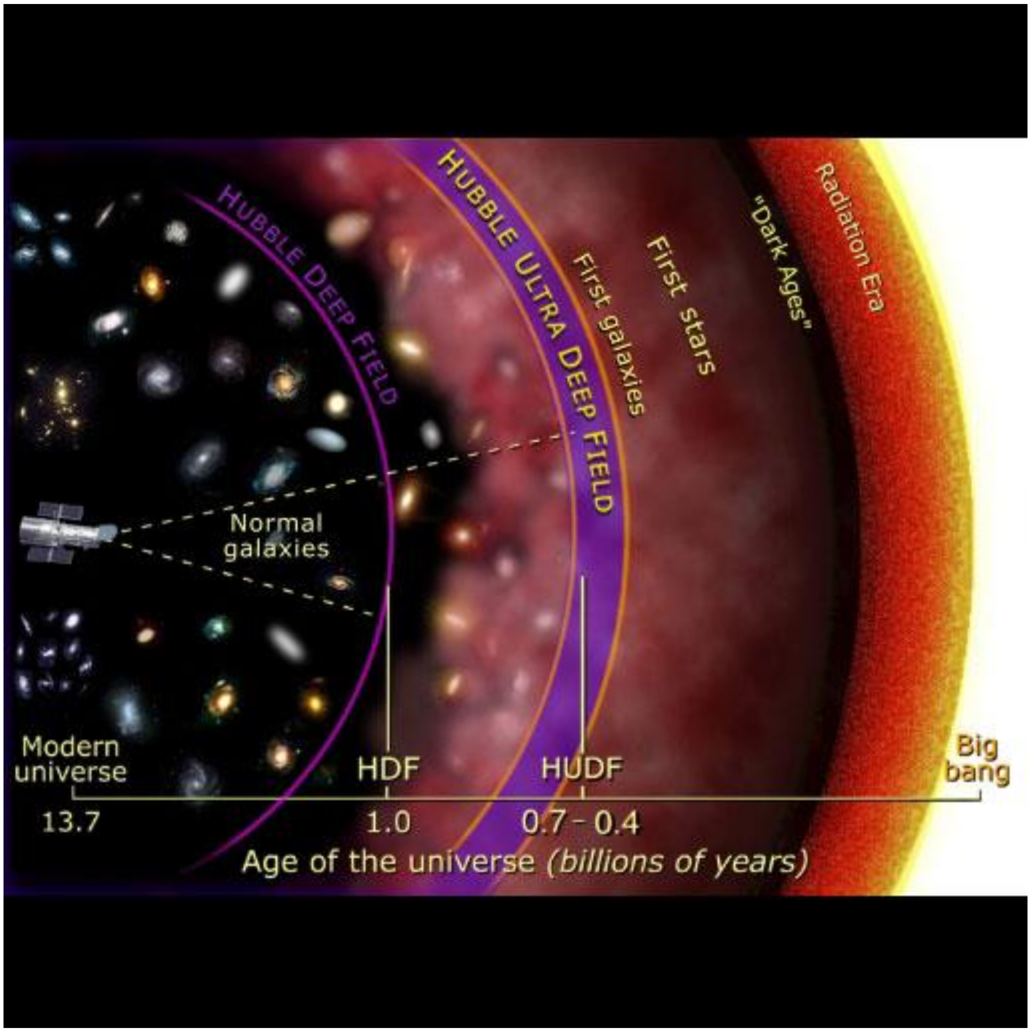
$E_k = \frac{1}{2} \times m \times v^2$, where m is mass, and v is the velocity.

To find where the object is, while it is falling from a tall building, here is the formula.

$S = \frac{1}{2} \times a \times t^2$, where s is distance, a is acceleration or g, and t is time.

Cosmologists were trying to find out whether our Universe will expand forever or will it end up in a big crunch. Writer **Rudi Tseng speculates that our Universe had gone through several bounce, and every bounce it made, it gain more energy and matter**.

A Timeline of the universe



This timeline of the universe demonstrates how far back the current generation of deep images bring us. For example, galaxies seen in the Hubble Ultra Deep Field (the deepest image ever taken by human kind) date to as early as 700-900 million years after the Big Bang (5-7% of the age of the universe). Since the first galaxies and stars are thought to form just 200-300 million years after the Big Bang, current observations are now bringing us very close to first light.

OUR GOAL IS TO IMPROVE OUR QUALITY OF LIFE AND TO ADVANCE OUR SCIENCE AND TECHNOLOGY

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