How do I build a universe?
Chalk Talk
March 5, 2010

The dot on an 'i' can hold 500,000,000,000 protons—they're exceedingly microscopic. Now imagine if you can (and of course you can't) shrinking one of those protons down to a billionth of its normal size into a space so small that it would make all other protons look enormous. Now pack the tiny, tiny space in one ounce of matter. Excellent, you're ready to start a universe!

In order to start an old-fashioned Big Bang Universe, you'd need to pack everything there is and squeeze it into a spot so compact that it has no dimensions at all—it's known as a singularity.

What is a "singularity" and where does it come from? Well, to be honest, we don't know for sure. Singularities are zones which defy our current understanding of physics. They are thought to exist at the core of "black holes." Black holes are areas of intense gravitational pressure. The pressure is thought to be so intense that finite matter is actually squished into infinite density (a mathematical concept which truly boggles the mind). These zones of infinite density are called "singularities." Our universe is thought to have begun as an infinitesimally small, infinitely hot, infinitely dense, something - a singularity. Where did it come from? We don't know. Why did it appear? We don't know.

Imagine: no space, no darkness…no "around" around this singularity… it doesn't occupy any'thing'… more importantly, we can't ask how long it was hanging around because time doesn't even EXIST! There is no past...

T=0 (time equals ZERO!)

The very first second is what many cosmologists devote their entire lives and careers to… dividing this up small, understandable chunks of seconds. This is what changed everything!

Here's what scientists have divided this time up into…
Early Stages of the Universe: Inflation—creating something from nothing!

13.7 Billion Years Ago
Inflationary Period—the universe goes from something that we really can't understand to something that we can barely comprehend.
The universe was so SMALL you would need a microscope to view it.

After doing a lot of MATH and looking at the behavior of protons in particle accelerators, scientist can look back to 10^{-42} seconds after the moment of creation. (This is one 10 million trillion trillion trillionths of a second!)

- lasted about 10^{-32} of a second
- space expands by a factor of about 10^{25} times
    - from a size much smaller than a proton

- to the size of a softball

In 1965 two young radio astronomers made an extraordinary discovery—they heard a noise that was unrelenting and unfocused that came from every point in the sky, day and night, through every season. They cleaned their dish with brooms, scraped all the bird poop away, duct taped all their seam and rivet... This was the cosmic background radiation left over from the Big Bang! (show photo in Bryson Book)

By the time it crossed the vast cosmos, the radiation would reach the Earth in the form of microwaves. They found the edge of the universe and they were 'seeing' the first photons—the most ancient light in the universe but through time and distance it had been converted into microwaves!

Tune your TV to any channel it doesn't receive and 1% of the dancing 'static' you see is due to the Big Bang… next time you complain that there's nothing on, you can always watch the birth of the universe.

What causes the expansion? It wasn't actually a BANG… but rather an expanding…
Need to consider two ideas:

- "negative" gravity **Negative gravity**: - repulsive gravity (pushes matter apart) which would be possible under the conditions expected in the early universe

- Unification of Forces

Four Forces of Nature were established during this time period:

1. gravity
2. electromagnetic force (the force that bonds solids, liquids, gases and plasma—attracts particles of like electrical charge and repels like charges)
3. strong nuclear force short range (bonds protons/neutrons in the nucleus together)
4. weak nuclear force (also short range, observed in radioactive decay)

At very high energies - these four all behave like ONE force (unification) the VERY early universe may have had this unification

1. 10^{-43} seconds - gravity breaks away (other three still unified)
2. 10^{-35} seconds - strong nuclear force breaks away
3. 10^{-11} seconds - weak nuclear and electromagnetic forces separate

As forces separate: energy is released
Energy can be converted to mass
Mass is pushed apart by negative gravity

Everything seems just right… but in the end, it may happen that gravity may turn out to be a little too strong and one day may halt the expansion of the universe and bring it collapsing in on itself (possibly to start the whole process over again). Or, on the other hand, it may be too weak and cause the universe to keep racing away forever until everything is so far apart there is no chance of material interactions and then it's inert, and dead, but very roomy. Or

maybe, it's just right… which will allow the universe to hold together at just the right dimensions to allow things to go on indefinitely.

There's LOTS of heat, 10 billion degrees, enough to begin the nuclear reactions that will eventually create the light elements (hydrogen and helium)

In THREE minutes, 98% of EVERYTHING there IS or EVER WILL BE in the universe has been produced!

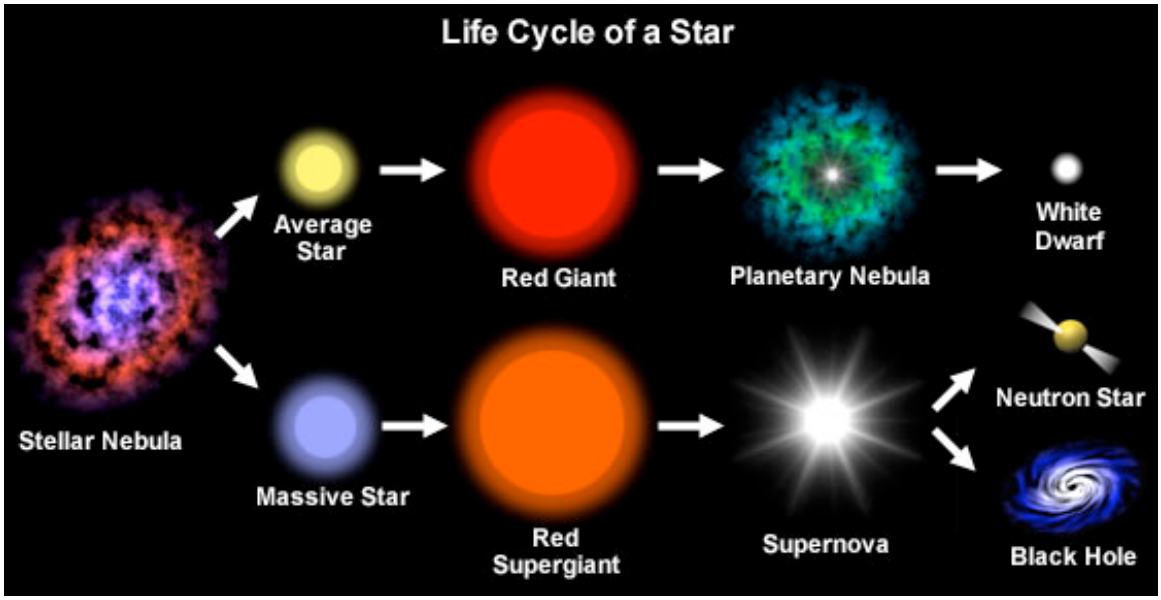
Suddenly there are swarms of protons, electrons and neutrons. Great nebula cloud—this great swirl of gas and dust begins to assemble in space. 99.9% of it goes to make up our Sun (helium, hydrogen, dust, some metals and substances like water, methane and ammonia) due to gravity condensing it into a dense central region and a diffuse outer region.

The swirling, rotating disk was like a great centrifuge… grains of dust and ice collided and became stuck together which eventually started to build our planets. Only rocky material and metals could withstand the heat closest to the protosun… so the planets closest to today's sun are made of these materials. Venus and other inner rocky planets were formed in a molten state and later partly solidified.

The outer part of the disk the rock and ice planets became big enough to attract large amounts of gas and are known as the gas giants.

Leftover materials for planets are thought to have become comets and asteroids.

At some point about 4.4 bya, an object the size of Mars crashed into the earth and blue out a small clump that formed into the rock we call our moon. Most of this material comes from Earth's mantle, not the core, and thus has very little iron.



Low mass star (less than ½ that of our sun) has used up the hydrogen at its core it will convert hydrogen to helium and collapse. The temperature and pressure will not get high enough for helium to burn, so it will cool and gradually fade → into a small, dim, black dwarf

Average star—our sun exhausts the hydrogen in its core, it becomes a red giant and loses its outer layers to produce a planetary nebula. It eventually collapses and the temperature and pressure innate helium burning. The start expands before finally collapsing into a white dwarf that gradually fades to black an no longer emits heat or light.

High-mass star—the mass will dictate the temperature of the core…. Different elements are produced at each stage. If the star is massive enough, an iron core is formed, but elements heavier than iron cannot be formed within stellar cores, they are formed in supernova (produces elements heavier than iron—remember the periodic table of elements) explosions that leave behind neutron stars or black holes… Or neutron—pulsars (pulsing neutrons)… if its mass is over 1.4 solar masses, it will be come a neutron star. If it is above 3 solar masses, it will collapse and become a black hole.

Sun (1 star of 100 Billion that make up the Milky Way, a large spiral galaxy which started 13.5 bya)

Remember the speed of light—circles earth 7 times in 1 second… The Milky Way is 15,000 by 6,000 light years long…

Mercury, Venus, Mars, Earth
Jupiter, Saturn, Uranus, Neptune, (Pluto)

Asteroid belt-between Jupiter and Mars' orbits
Comets (dirty snowball), low density
Meteors and meteorites—'shooting stars' small, dusty fragments of comets or asteroids that enter earth's upper atmosphere (eraser tip)

We are all stardust!