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Astro 1106

2 Aug 2022

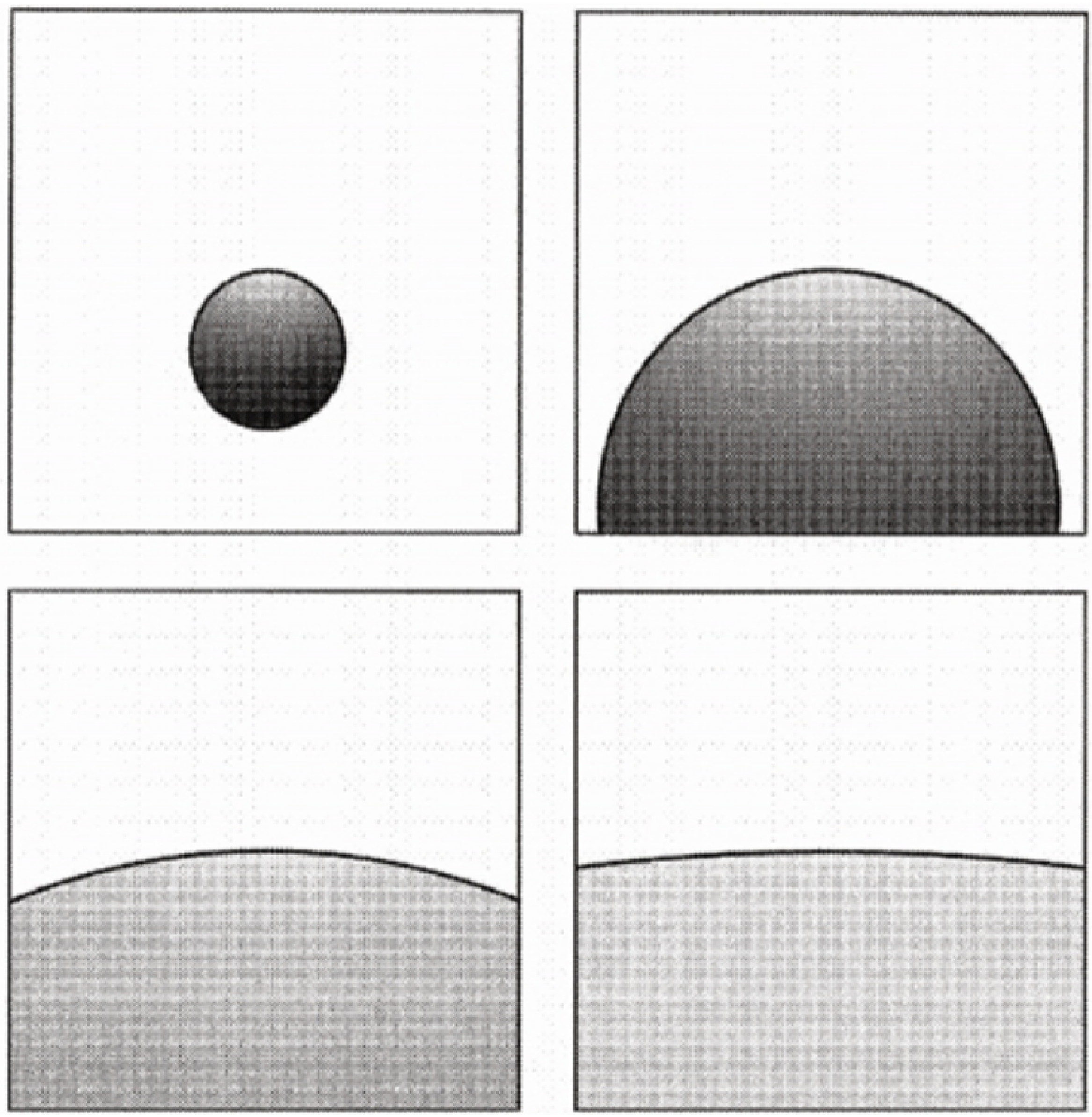
The Past and Future of the Universe

As we know, The Big Bang Theory describes the theory of how the universe spread out from a ball of high-density mass. Additionally, in another 10^10^10^56 years[1] from now, quantum fluctuations (random changes of energy within a particle)[2] will cause a new big bang to occur. We're only 13.8 billion years into our newborn universe and have an uncountable amount of years left. Since the Big Bang, our universe now houses billions of large galaxies that are spread apart and continue to get further apart as time goes on, we've observed seven different supernovae[3], and we've discovered black holes that are too big to make sense and universes too far to make sense. But, what will our humankind miss?

We can discuss the events of the past and future through the use of eras. With the help of the book, "The Five Stages of the Universe," we can divide the universe into 5 eras, or periods of time, to understand the events occurring in each time scale we look at. Before going too specific within each era, we can define what an era is and come up with a basic idea on what happens in each era. An era is a long period of time that has some distinct features. The timescales of our universe can be described through the five eras: the Primorial, Stellifierous, Degenerate, Black Hole, and Dark.[4] Each one describes a different period of time. The Primordial Era starts from 10^-50 to 10^5 years and contains huge events like the Big Bang Expansion and Nucleosynthesis (the production of other nuclei that aren't Hydrogen1)[5]. The next era, which is our current era, is the Stelliferous Era. Occurring from 10^6 to 10^14 years, stars are currently the most common object in our universe[5]. However, at the end of this era, many stars will have exploded into degenerate objects (black holes, white and black dwarfs, neutron stars, pulsars, quasars, and magnetars)[5]. This leads us to the Degenerate Era where the universe is filled with these degenerate bodies[5]. This era depicts events from 10^15 till 10^39 years after the big bang[5]. This is the time when proton decay starts to occur. Proton Decay is a theory that protons decay into pions and positrons. [6, 5] From then on, till 10^100 years after the Big Bang, The universe will go through the Black Hole Era, where all matter is in the form of a black hole. During this time, all of these black holes will slowly evaporate through the process of Hawking Radiation.[5] Hawking

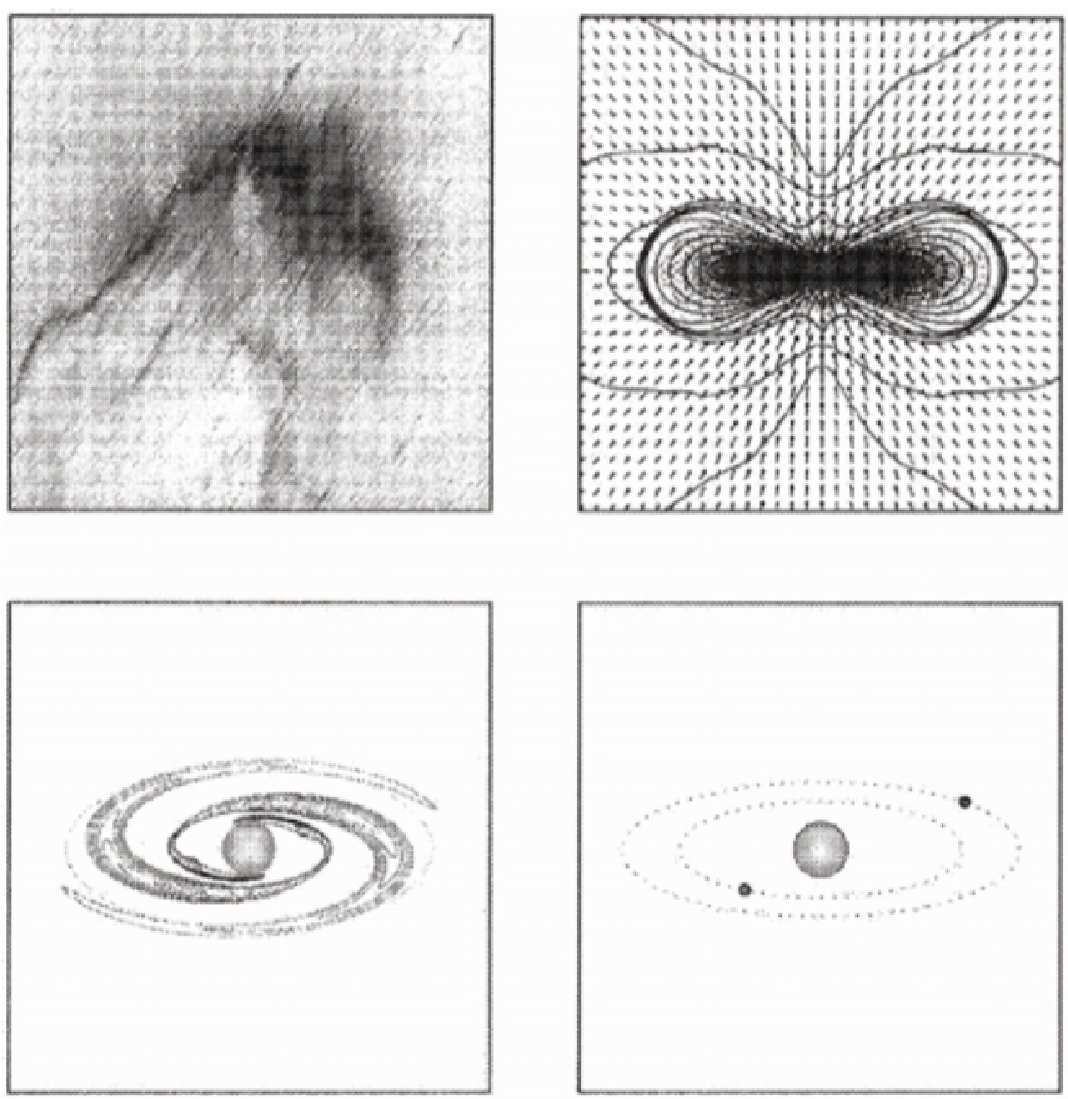
Radiation is the radiation that's released from a black hole.[7] After the Black Hole Era, we're left in the dark era till quantum fluctuations create a new big bang.[5] This is also when the universe will reach its final entropic stage and temperature. The universe will essentially have very little energy left while going through large periods of time.[5]

Before discussing our present and future eras, we should look at the Primordial Era. We're all familiar with the Big Bang Theory and Nucleosynthesis. It starts with the big bang. However, let's set the scene for what the beginning of the Primordial Era looked like. Imagine energetic particles huddled in such a dense ball of matter that expands exponentially. During Planck Time, in the first 10^-35 seconds of the universe, it expands at an incomprehensible speed.[8] As these particles are moving at incredible speeds, the universe is extremely hot. Because of this heat, the ordinary matter that we know off doesn't exist yet. The universe is filled to the brim with quarks (6 different elementary particles that make up protons, neutrons, and electrons)[9] that rapidly move around. At the age of around one microsecond old, we have examples of antimatter (opposing partner particles for the normal matter)[10] that make up just a little less than what the normal matter makes up. Right at around the 20-minute mark of expansion, atoms are starting to be made. [11] At this mark, the universe starts to cool down, as it will continue to for a long time to come. The universe at the moment is around 75% hydrogen with the rest being helium.[11] Along with that, the electrons that were created captured photons which removed the universe of its light.[11] It was still 3.8*10^5 years later that atoms could be stably formed.[11] Along with this, all of the radiation released from the expansion has created a map of photons around the universe called the Cosmic Background Microwave Radiation. This actually lets us visualize distances over 20 billion light years from each side of us.[8] Along with this, the universe continues to expand and the distances between objects continue to gradually increase. Einstein described inflation through this diagram.[8]



The diagram described how a small ball gradually got bigger and bigger from an upwards view. The details show how the curvature of the circle tends to keep flattening as the circle expands, similar to how our universe flattened out during inflation. The density of the universe has also reached a critical point, where we know that it is flat.[8] Throughout the course of the 10^5 years this era goes through, the universe expands further and cools down, making conditions for the Stelliferous Era possible.

We currently live in the Stelliferous Era. Starting 10^6 years after the Big Bang, the effects of gravity on the universe become more visible. It pulls smaller groups of matter into galaxy-type structures and pushes these galaxy-type structures away from each other.[8] At the beginning of this era, star formation is huge. Dense clouds of dust collapse to come together and form new cores for stars. Magnetic fields form around the cores to prevent them from collapsing.[8] As this happens, a protostar is formed. This is like a newborn star as it grows into a much larger star.[8] These clouds continue to spin around these newborn stars in order to feed them which lets them grow bigger. [8] When the protostar gets older, it starts using up more fuel and creates more energy and heat. This energy tends to glide around the star till it's fully grown and can start harboring planets.



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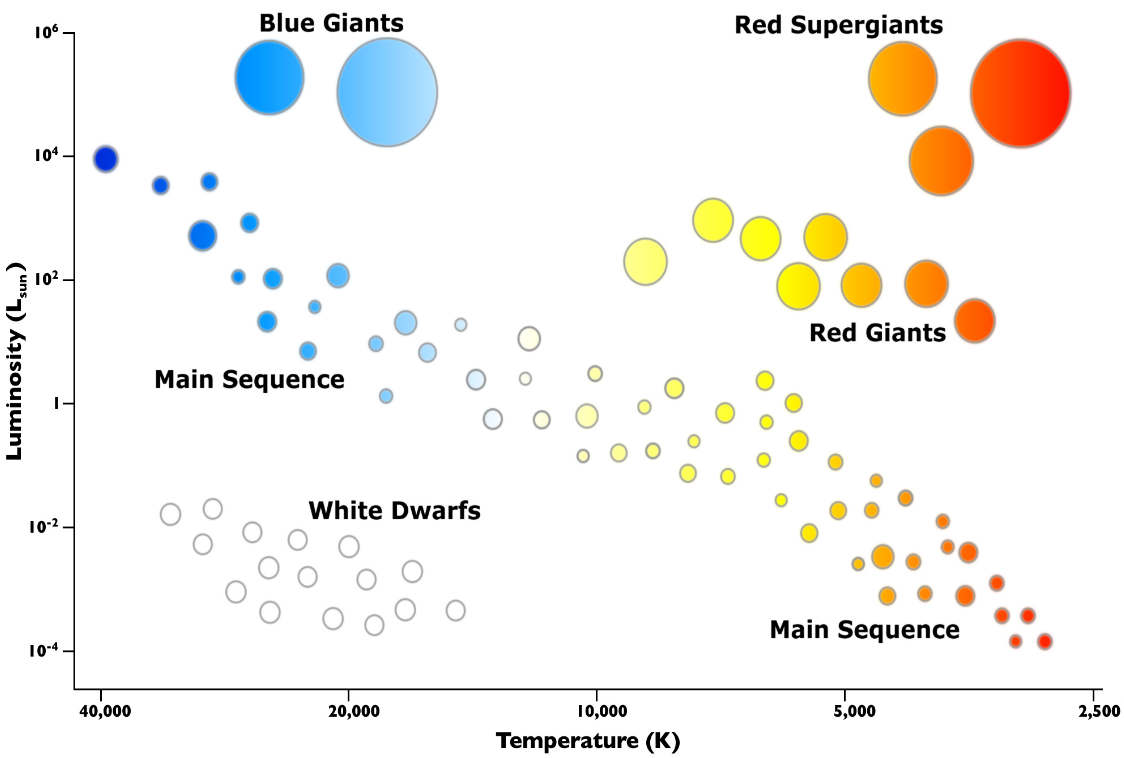
This diagram displays the life cycle of a star. The top left shows the molecular gas clouds, and to its right shows the protostar being formed. The bottom left shows a much more evolved protostar, and the final image shows a grown star with planets orbiting it.[8] Star formation is incredibly common during this era as this process happens everywhere throughout the universe. This process' repetition has left just our galaxy alone with over 1 billion stars. Considering there are billions of galaxies in the known universe, this process has happened a lot. However, most stars continue growing across something known as the Hertzsprung-Russel Diagram, which models stars based on luminosity and temperature.



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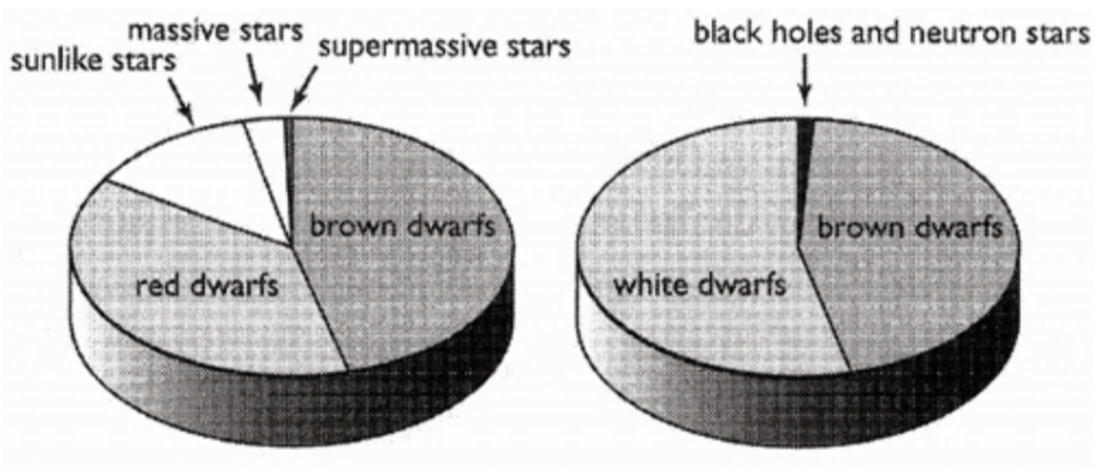
Most stars start off at the lower right corner then tend to become red giants and finally turn into white dwarfs in the degenerate era. Meanwhile, main sequence stars towards the top right usually become blue giants then other degenerate matter.[8] This was created in this era to be able to classify stars. An example of this is our sun. It started off as nothing more than a protostar nearly 4.6 billion years ago and will grow into a red giant within another few billion years, the sun will move up to the Red Giants section on the H-R Diagram. Along with that, the heavier stars that are created are able to fuse heavier elements in their cores. Towards this era, however, most stars that are created will also turn into degenerate matter. At 10^14 years after the big bang, this marks the end of star formation and the beginning of a universe filled with degenerate matter.

For the next 10^25 years, the universe turns into a land filled with dead stellar remnants.[8] Degenerate remnants refer to stars and other objects made of degenerate matter (matter with such high gravitational pressure that its physical effects are extreme)[13]. Almost all the stars we see in our nighttime sky have become brown or white dwarfs, neutron stars, or black holes. This pi chart from[8] describes the change in the type of objects from the Stelliferous Era to the Degenerate Era.



Brown dwarfs are brown colored degenerate stars that are usually smallest and lightest of all the degenerate remnants.[8] They are unable to fuse hydrogen in their cores so they usually live for extremely long periods by cooling off ever so slightly as time passes.[8] The smallest star that could continuously go through nuclear fusion have a minimum of 8% of the sun's mass. The most common brown dwarves usually have a radius of around 1/10th of the suns.[8] Despite being called brown dwarves, they can appear orange, red, or even magenta.[14] White dwarves are extremely common as it is the endgame for most main sequence stars. Any star between 0.08 to 8 solar masses will turn into a white dwarf. The highest mass for a white dwarf is 1.4 solar masses, which is known as the chandrasekhar limit. In fact, white dwarfs get smaller as they get more massive.[8] They tend to live for incredibly long periods of time as they slowly burn their fuel. However, at the end of their lifetimes, they explode in type 1a supernovae.[15] Next, there are neutron stars. These tend to be 10^9 times denser than white dwarves. Because of its incredible density, protons and electrons take the form of neutrons which then become degenerate.

1 https://en.wikipedia.org/wiki/Timeline_of_the_far_future#cite_note-prob-13
2 https://en.wikipedia.org/wiki/Quantum_fluctuation
3 https://astronomy.com/news/2020/11/7-naked-eye-supernovae-throughout-human-history
4 https://en.wikipedia.org/wiki/The_Five_Ages_of_the_Universe
5 https://en.wikipedia.org/wiki/Big_Bang_nucleosynthesis
6 https://en.wikipedia.org/wiki/Proton_decay
7 http://www.scholarpedia.org/article/Hawking_radiation
8 The Five Stages of the Universe: Inside the Physics of Eternity: Fred Adams and Gregory P Laughlin
9 https://en.wikipedia.org/wiki/Quark
10 https://en.wikipedia.org/wiki/Antimatter
11 https://bigthink.com/hard-science/5-universe-eras/
12 was an image here is the image address https://useruploads.socratic.org/fiSP0m0ARcuU0oeaTZun_hr_diagram.jpg) https://socratic.org/questions/what-is-the-hertzsprung-russell-diagram-and-why-is-it-so-important-to-astronomy
13 https://en.wikipedia.org/wiki/Degenerate_matter
14 https://en.wikipedia.org/wiki/Brown_dwarf
15 https://www.space.com/23756-white-dwarf-stars
16 https://www.jpl.nasa.gov/images/pia23863-different-types-of-neutron-stars-illustration
17 (image address https://i.dailymail.co.uk/1s/2021/03/29/16/41084256-9414291-image-a-1_1617031386418.jpg) https://www.dailymail.co.uk/sciencetech/article-9414291/Astronomers-discover-elusive-Goldilocks-black-hole-55-000-times-mass-sun.html
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