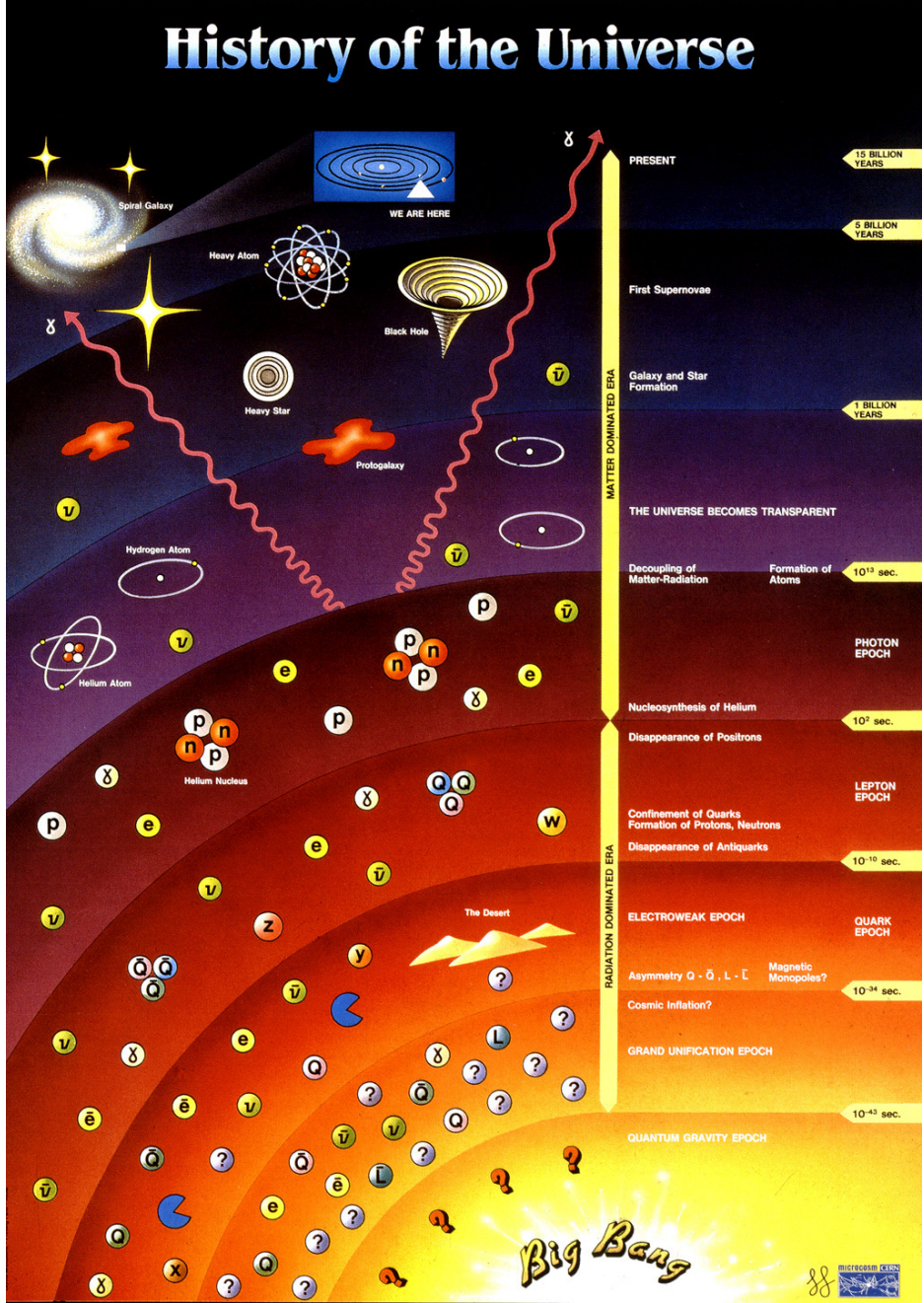


“The Birth of the Universe”
Newcomer Academy High School
Visualization One

| Chapter | Topic | Key Points of Discussion | Notes & Vocabulary |
|---------|------------------------------|---|--|
| 1 | Birth of the Universe | <p>The Big Bang Theory</p> <p>How and when did the universe begin?</p> <ul style="list-style-type: none"> Approximately 13.7 billion years ago, all the matter and energy in the universe were created in an enormous explosion known as the “Big Bang”.  <ul style="list-style-type: none"> The universe expanded and cooled and is still doing so today-evidence Doppler Red-shift. | <p><i>Activity 4A</i></p> <p>Matter</p> <p>Universe</p> <p>Big Bang</p> |

Simulate the “Big Bang” utilizing Uniview 1.5.5
Fly through the Universe towards the Earth
Along the way discuss the following pieces of evidence (stated below)

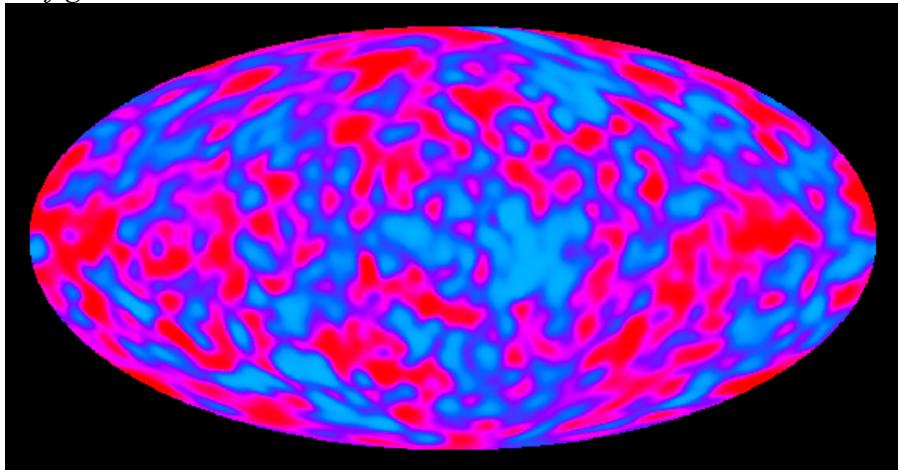
Evidence of Big Bang Theory

Evidence, Inference, and Theory

What is the compelling evidence that supports the Big Bang Theory?

Cosmic Background Radiation

- **Cosmic Background Radiation** (CBR) is the energy released as matter and antimatter annihilated each other, during the Big Bang.
- The CBR is a nearly uniform radiation received from all regions of the sky.
- The evidence is apparent as a radio signal with a temperature of 2.7K and is thought to be the cooled afterglow of the Big Bang.
- Amazing Fact Alert: 2.7K doesn't seem to represent that much energy but in fact the total energy in the CBR is *greater than all the energy generated by all the stars in the universe since the formation of galaxies and stars!*



The Elemental Composition of the Universe

- Using powerful telescopes, scientists have made extensive **spectroscopic** surveys of distant stars and galaxies. The data indicates that hydrogen and helium make up nearly all of the nuclear matter in the universe. The most abundant **element**, hydrogen, accounts for 74% of the mass while helium contributes 25%. Heavier elements comprise less than 1% of the total.
- The observed 3:1 ratio of hydrogen to helium along with the relative scarcity of heavier elements yield critical clues about the density, temperature, and expansion rate of the early universe. The correlations between these observations and the predictions of the Big Bang model are striking pieces of evidence in support for the theory.

Doppler Red-Shift Evidence

- The **Doppler red-shift** of light observed from distant stars and galaxies gives evidence that the universe is expanding (moving away from a central point). This allows for Big Bang Theory, because after a “bang” occurs all of the matter moves away from the point of origin.

Key in on that this is a theory based on inferences made by examining evidence

Activity 4B

Doppler Red-Shift

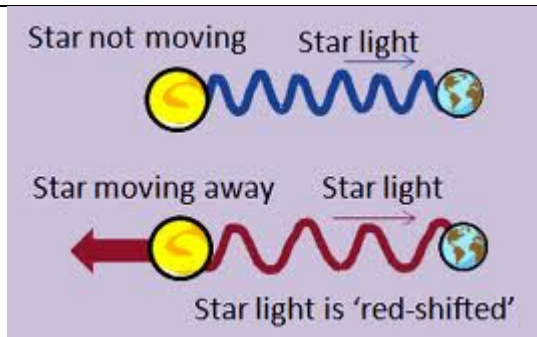
Light Spectrum

Spectroscopic

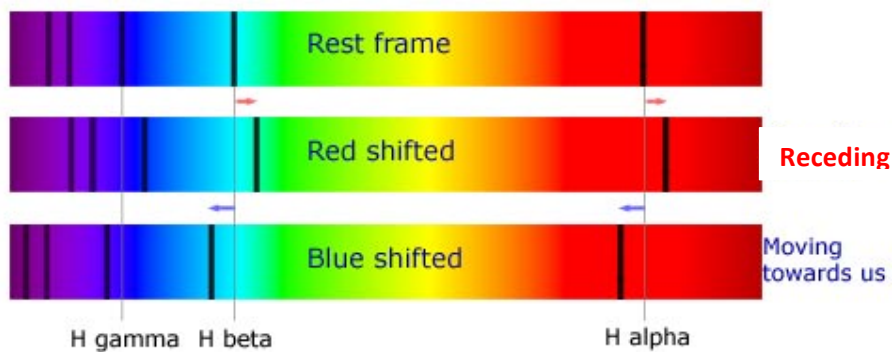
Cosmic Background Radiation

Element

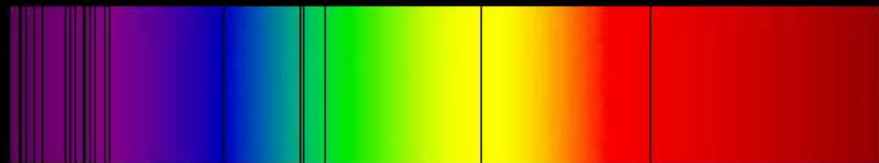
Composition



- As the light moves away from an object the distance between its waves becomes greater. This is displayed by red light, where the waves are further apart (longer).
- The opposite is evidence of blue light, where the waves become compressed as the object moves closer.
- When **spectroscopic** information is processed, an object that displays a red-shift is moving away (receding) from the viewer; and an object that displays a blue-shift is moving towards the viewer.




Absorption Lines from our Sun



Absorption Lines from a supercluster of galaxies, BAS11 $v = 0.07 c$, $d = 1$ billion light years



| | | | |
|----------|--|--|---|
| <p>3</p> | <p>Where Do Elements Come From?</p> | <p>Matter vs. Antimatter</p> <ul style="list-style-type: none"> • In the smallest of fractions of the first second after the Big Bang, what was once a complete vacuum began to evolve into what we now know as the Universe. • In the very beginning there was nothing except for a plasma soup, a single point of infinite energy. Science has devised a theory of what happened, based on inferences determined by the evidence found in the universe of today. • Immediately after the Big Bang, the universe was tremendously hot as a result of particles of matter and antimatter rushing apart in all directions. • As it began to cool, at around 10^{-43} seconds after the “bang”, there existed an almost equal yet asymmetrical amount of matter and antimatter. • As these two materials are created together, they collide and destroy one another creating pure energy. Fortunately, there was an asymmetry in favor of matter. • As a direct result of an excess of about one part per billion, the universe was able to mature in a way favorable for matter to persist. • As the universe first began to expand, this discrepancy grew larger. The particles which began to dominate were those of matter. They were created and they decayed without an equal creation or decay of antimatter. • <i>As the universe expanded further, and thus cooled, common particles began to form. These particles called baryons that include photons, neutrinos, electrons and quarks. These would become the building blocks of life as we know it.</i> • <i>During the baryon genesis period there were no recognizable heavy particles such as protons or neutrons because of the still intense heat. At this moment, there was only a quark soup.</i> • <i>After the universe had cooled to about 3000 billion degrees Kelvin, a radical transition began which has been likened to the phase transition of water turning to ice. Composite particles such as protons and neutrons, called hadrons, became the common state of matter after this transition.</i> • <i>Still, no more of complex matter could form at these temperatures. Although lighter particles, called leptons, also existed, they were prohibited from reacting with the hadrons to form more complex states of matter. These leptons, which include electrons, neutrinos and photons, would soon be able to join their hadron kin in a union that would define present-day common matter.</i> • After about one to three minutes had passed since the creation of the universe, protons and neutrons began to react with each other to form deuterium, an isotope of hydrogen. • Deuterium, or heavy hydrogen, soon collected another neutron to form tritium. Rapidly following this reaction was the addition of another proton which produced a helium nucleus. Scientists believe that there was one helium nucleus for every ten protons within the first three minutes of the universe. • After further cooling, these excess protons would be able to capture an electron to create common hydrogen. • Consequently, the universe today is observed to contain one helium | <p>Matter</p> <p>Antimatter</p> |
|----------|--|--|---|

| | | | |
|---|---|--|---|
| | | <p>atom for every ten or eleven atoms of hydrogen.</p> <ul style="list-style-type: none"> While it is true that much of this information is speculative, as the universe ages we are able to become increasingly confident in our knowledge of its history. By studying the way in which the universe exists today it is possible to learn a great deal about its past. Much effort has gone into understanding the formation and number of baryons present today. Through finding answers to these modern questions, it is possible to trace their role in the universe back to the Big Bang. Subsequently, by studying the formation of simple atoms in the laboratory we can make some educated guesses as to how they formed originally. Only through further research and discovery will it be possible to completely understand the creation of the universe and its first atomic structures, however, maybe we will never know for sure. | |
| | | <p>Hydrogen and Helium What were the first elements formed?</p> <ul style="list-style-type: none"> Primarily Hydrogen and Helium. (Primordial-originated in the Big Bang, not via nucleosynthesis in stars) By viewing light from space, scientists know that the current composition of the universe is 99% H and He | <p>Primordial</p> <p>Hydrogen</p> <p>Helium</p> |
| <p>Movie Clip of “Big Bang” – Displaying Aforementioned Points of Emphasis</p> | | | |
| <p>4</p> | <p>The Life of Two Stars (Intro)</p> | <p>Star Formation What is a Star?</p> <ul style="list-style-type: none"> A star is a massive collection of gas and dust that emits light produced in its core as a result of nuclear fusion. The massive ball of dust and gas is held together by its own force of gravity. The thermal energy produced by the fusion reactions in the star’s core counteracts the force of gravity. The balance of these two forces prevents the star from collapsing onto itself.  <p>How does a Star Form?</p> <ul style="list-style-type: none"> A star is formed from an interstellar cloud of dust and hydrogen gas this cloud is known as a nebula. The nebula is pulled closer and closer together under its own force of gravity. As the dust and gas particles become more and more dense, they collide more frequently. More collisions cause friction which makes the core temperature soar. At this stage the contracting cloud begins | <p><i>Activity 4A</i></p> <p>Nebula</p> <p>Protostar</p> <p>Star</p> <p>Gravity</p> <p>Density</p> <p>Friction</p> <p>Fusion</p> |

to glow and it is called a **Protostar**.

- If there is enough matter in the Protostar, gravity continues contracting the gas and dust and the temperature climbs to 15 million Kelvin. This extreme heat and pressure causes the hydrogen atoms to move so fast and furiously that they crash into each other and stick together. This process, known as nuclear **fusion**, marks the birth of a star.
- The energy that is emitted in the fusion reaction moves to the outer layers of the giant ball and is released into space as light energy. (photons)

Extension:

- Formation of our Solar System, Earth, and Moon.

Movie clip of “Birth of a Star”