Beginning of the Universe

Curricular Materials Prepared by
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Scientific Summary:

The universe emerged 13.7 billion years ago in a moment that is commonly called "the Big Bang," but which we refer to as a "great flaring forth." In the earliest moment of the great flaring forth, all of the matter, energy, space, and time of the observable universe rushed out from a single, dense point. It was a moment of great heat, reaching trillions of degrees, in which boundless amounts of light and heat expanded quickly outwards.

While our universe is certainly expanding, as was observed by Edwin Hubble in the 1920s, there were also strong powers of attraction at play in the early development of the universe. From the very first moments, gravitational, strong nuclear, weak nuclear, and electromagnetic interactions played a role in shaping the unfolding of the universe

Within the first few microseconds of the beginning of the universe, tiny elementary particles called quarks and leptons were brought forth. The quarks quickly combined into protons and neutrons. Energetically churning about and colliding with one another, these first particles formed a dense, gluey form of matter called plasma.

After a few minutes, the protons and neutrons began to combine together in small clusters, called nuclei. These nuclei were constantly torn apart by the violent collisions caused by the vast energy of the early universe. A great deal of energy was expended in these collisions and breakages, some of which took the form of intense flashes of light. Due to the rapidity of these interactions and the density of the early universe, if we could observe it at this point in its expansion it would appear to be a profoundly luminescent, smooth burst of light.

As the universe expanded, it cooled. Due to this rapid decrease in density and temperature, conditions became hospitable to more complex formations of elementary particles called atoms. The hydrogen and helium atoms are the most common of the galaxy and they are, at least in some sense, the building blocks upon which the other atoms are built. In these early stages of the universe, hydrogen and helium were the first to atoms to form from the vast ocean of light and energy of the great flaring forth. While hydrogen and helium make up the vast bulk of atoms in the universe, small amounts of other atoms formed at this time such as lithium. The formation of these first atoms, the early interactions between energy and matter, and the creative interaction between forces

of attraction and repulsion set the stage for the formation of more complex structures including galaxies and stars.

Discussion Questions:

1. The *Journey of the Universe* book says that cultures organize themselves around stories about what they hold to be valuable, beautiful, and essential. Identify some of the values that are embedded in this "universe story." Imagine a future time when this or similar universe stories are told throughout the planet. Would their telling have any effect on the form and functioning of society?
2. The entire universe, even from these very first moments, has always been bound together by forces of attraction such as gravity. How would the universe story change if these forces of attraction did not exist? Identify some of the forces of attraction in the human realm. How would society change if these were to cease to exist?
3. In the *Conversations*, Joel Primack tells us that "almost everything in the universe is invisible." What does he mean by this?
4. What part of this story evokes awe or wonder in you?
5. Take an image, scene, or paragraph from *The Journey of the Universe* film, book, or *Conversations* that you feel conveys an important idea in regards to the first moments of the observable universe. Using an appropriate medium (i.e. prose, poetry, dance, painting, music, the spoken word, etc.), reformulate and express this idea in your own way. After doing so, reflect on how that helped you to better understand the great flaring forth.
6. The *Journey of the Universe* book uses the image of a seed to describe the development of the early universe. What other images occur to you? Does the choice of an image or metaphor to describe a process in the universe affect the way we think and feel about the process?
7. What aspects of your existence were actually present at the Flaring Forth? What does this imply about who you are and your relation to the cosmos?

Online Resources:

- The Wilkinson Microwave Anisotrophy Probe (WMAP), launched in 2001, has brought back some of our most revealing data regarding the early moments of the universe. It has mapped the Cosmic Microwave Background, which is light from the beginning of the universe. And, it has provided countless pieces of data which has allowed scientists to accurately discern the age of the universe (13.73 billion years old); it allowed scientists to determine the exact amounts of dark matter, dark energy, and ordinary matter in the observable universe; and it allowed them to determine what occurred in the first trillionth of a trillionth of a second of the great flaring forth. A predecessor to WMAP was the Cosmic Background Explorer (COBE), which was launched in 1989. Also be sure to explore the website for the Planck mission.

- Much of what we know about the first moments of the universe as well as the formation of the first particles comes from projects such as the Large Hadron Collider (LHC).
- The Hubble Telescope is one of our greatest tools for observing galaxies and stars from the early moments of the universe. Visit the Hubble Telescope website for an interactive tutorial features videos, animations, and images depicting the attractive force of gravity, early supernova, and more moments from the early universe as seen through the Hubble Telescope.
- The National Aeronautics and Space Administration (NASA) has a page on the first moments of the universe as well a page on dark matter and dark energy that can be used to accompany Joel Primack's discussion with Mary Evelyn Tucker in the *Conversations*.
- A variety of images, educational videos, and news on the formation and observation of the universe can be found at the California Institute of Technology's website for the Spitzer Space Telescope. Students can explore similar resources from the Chandra X-ray Observatory such as videos and podcasts.
- The Hayden Planetarium hosts a number of useful educational tools such as the Digital Universe Atlas, the Astrophysics Visualization Archive, and a plethora of useful links, news items, multimedia and programs such as this video on Cosmic Microwave Background.
- NASA's "Astronomy Picture of the Day" website features daily pictures of galaxies and other astronomical bodies. Each photograph is accompanied by explanations, links, and other useful information written by professional astronomers. This photo of Cosmic Microwave Background from the WMAP is an importance piece for understanding the great flaring forth.
- Go to the Yale Forum on Religion and Ecology's website for a comprehensive list of links to scientific organizations and educational resources.

Print Resources:

- *Journey of the Universe* Bibliography.
- Bibliography on Cosmogenesis from the Yale Forum on Religion and Ecology.

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