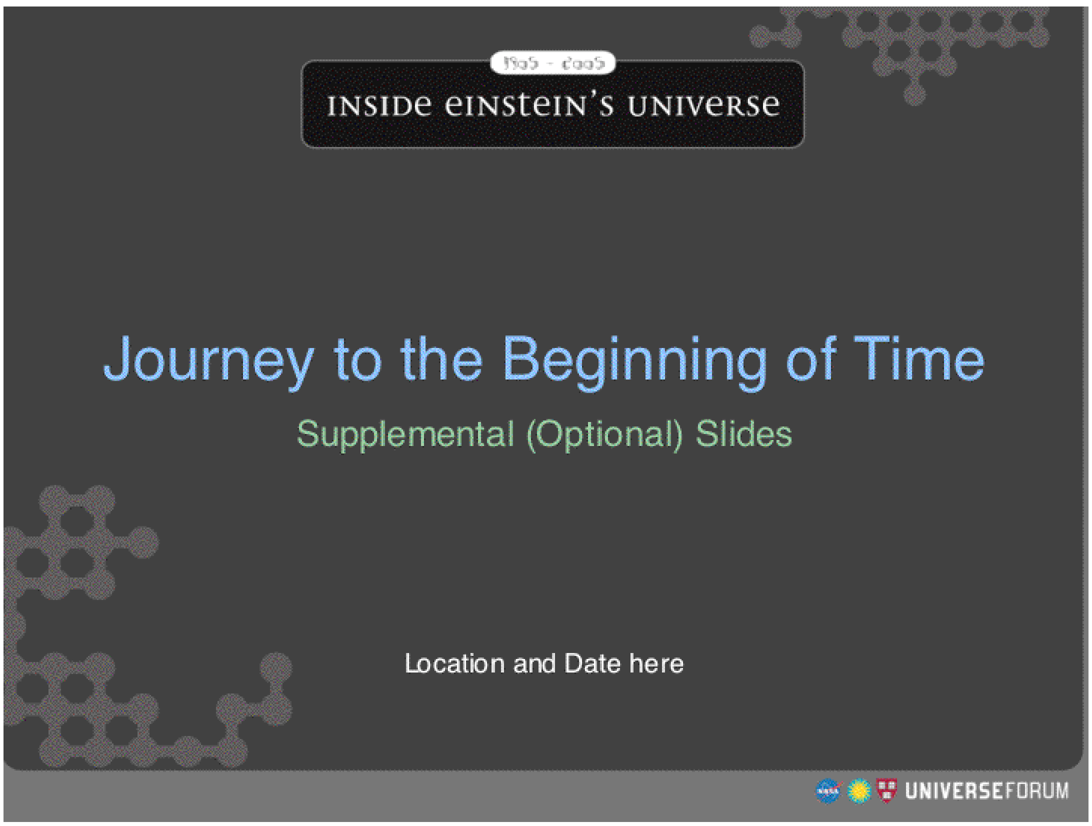
INSIDE EINSTEIN'S UNIVERSE

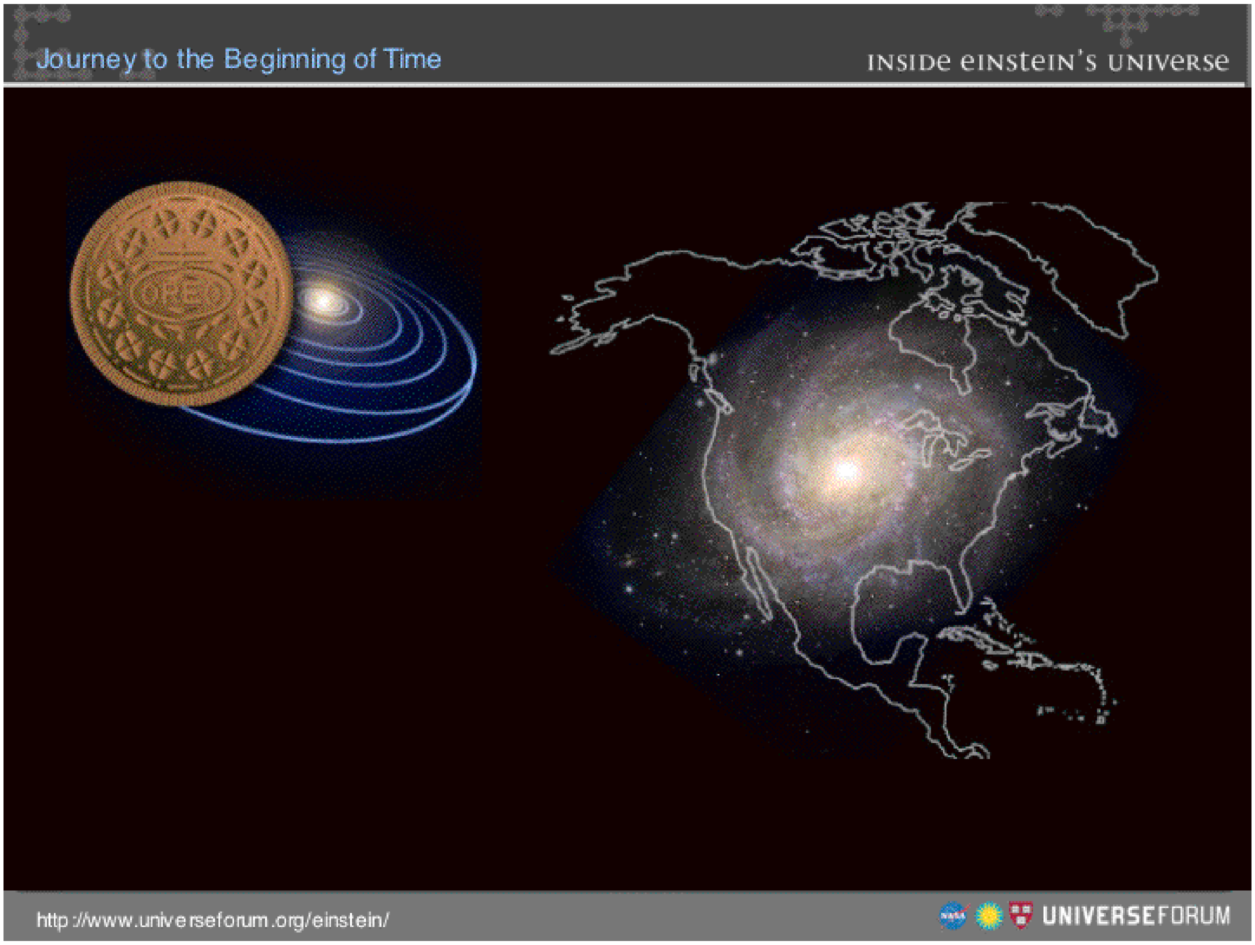
This document was created for people who do not have access to Power Point. It contains screen shots of the images and notes in the supplemental “Journey to the Beginning of Time” presentation. Though we cannot supply you with all of the included images, this document should give you an idea of the images used so that you can create your own slide show to accompany the “Journey to the Beginning of Time" demonstration.



In this presentation, we will:

- Create a scale model of the universe using everyday objects
- Explore the idea of “lookback” time
- See what our observable universe looked like in its infancy.

The slides contained in this presentation offer additional content and visuals for presenters wishing to modify parts of the demonstration. They are not intended to be a comprehensive presentation.



The presentation that these slides accompany uses everyday objects to create a scale model of the universe. In the first step, we imagine the solar system the size of a cookie. The entire Milky Way galaxy would be the size of North America.

Alternate Demonstration:
Suggested Visual: a football field and birdseed

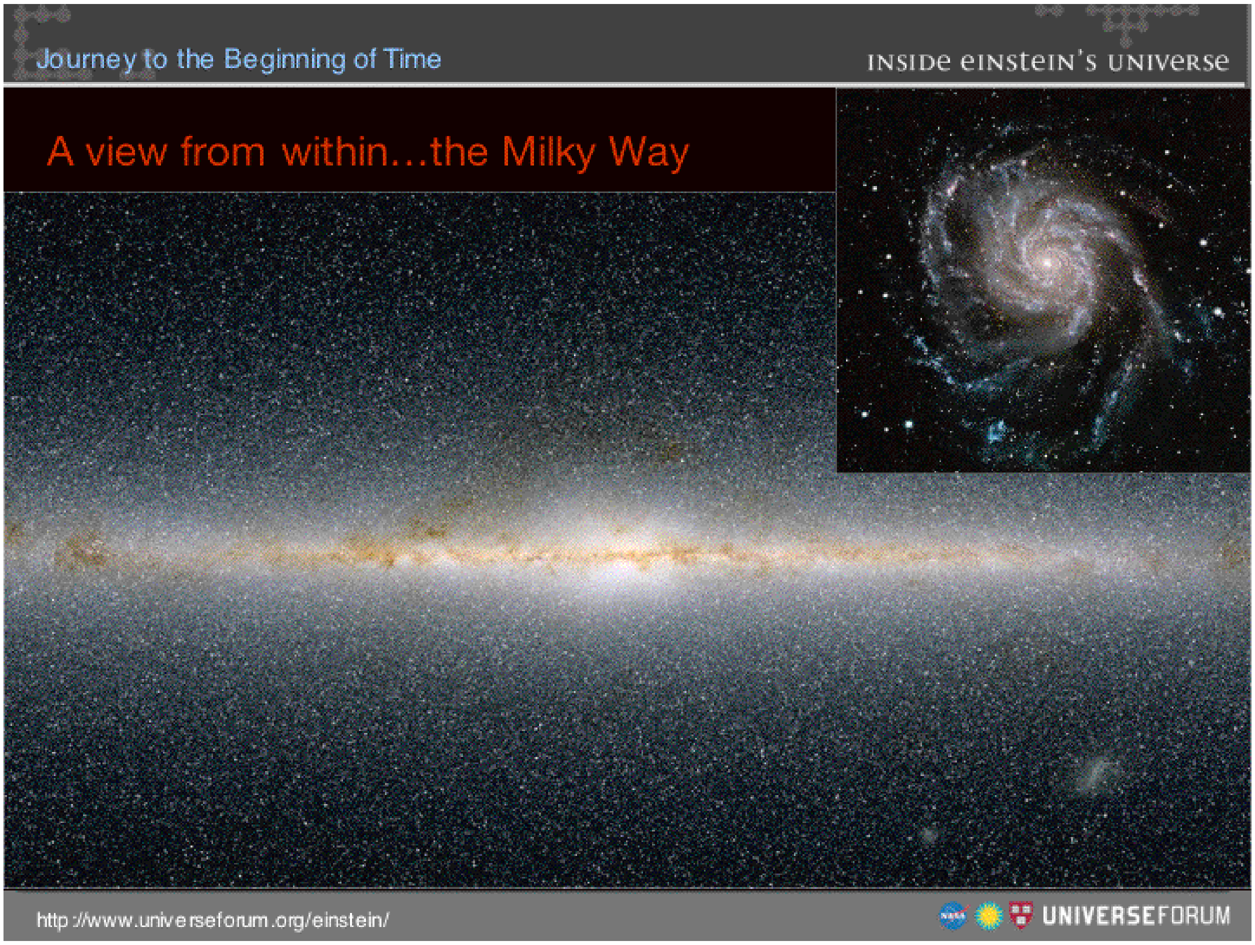
If you are using a larger object, such as birdseed, to represent stars, you can ask your audience to picture a football field. Now have them build a wall around the field that is four feet high. If you have any audience members who are four feet tall, they may want to help you with this next step. You are going to build a wall (metaphorical, of course) four feet tall around that football field and fill it with birdseed.

This slide contains two images - one of an empty field, underneath, and one of a field with birdseed, on top. The slide is animated so that the birdseed appears with a click of the mouse.
(You may wish to insert your own favorite football field image; the Universe Forum's choice of field does not reflect the views of NASA or any of its employees.)

Optional Slide “A view from within, #1”

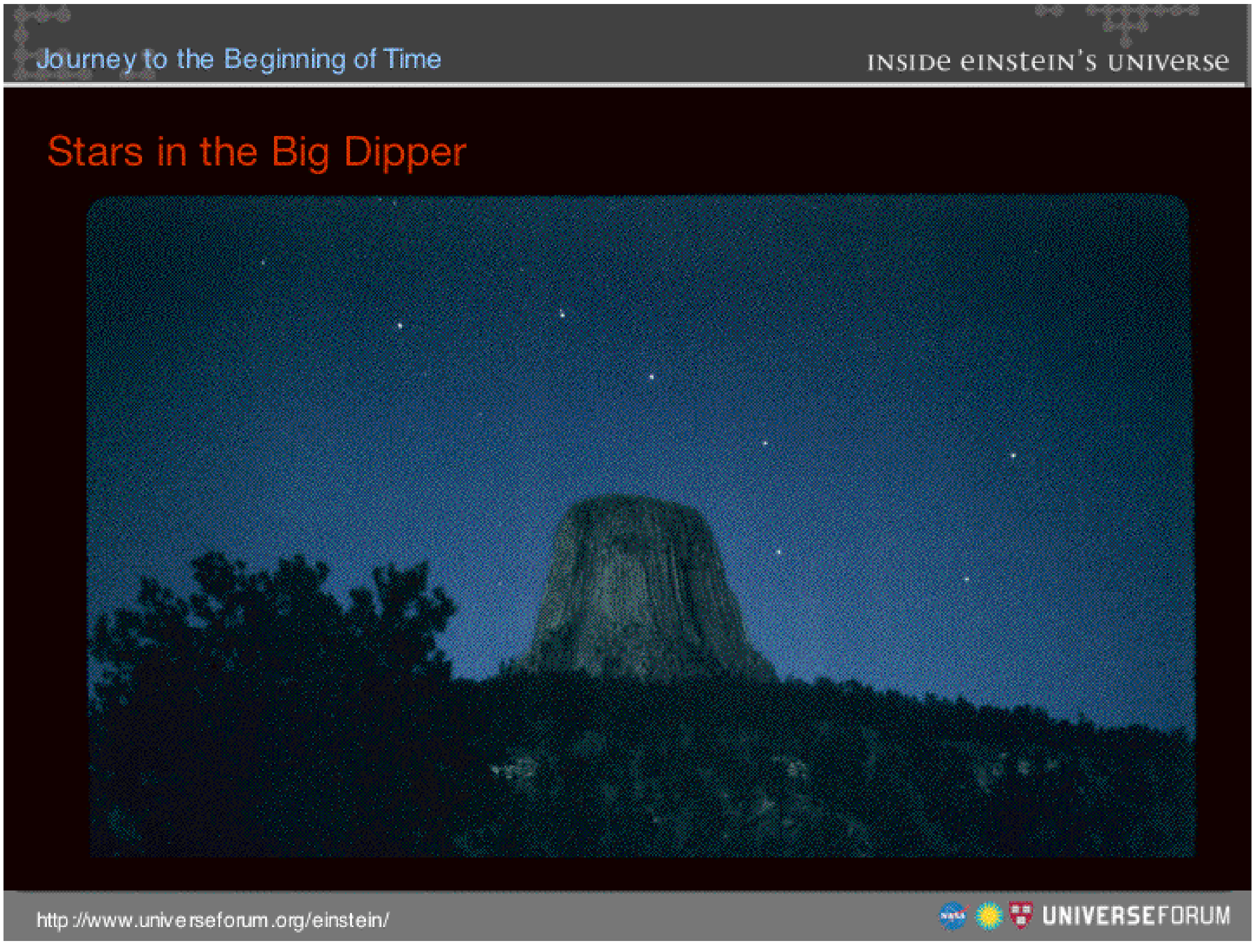
Looking at our Galaxy from our place in Earth is like trying to look at a city from inside. We do not have the time or technology to leave the Milky Way to view it from the outside. If we try to look at North America from within a city, we see only the nearest objects to us. If this were the only perspective of a city you could see, how could your determine the full extent of the city or your location within it?
(mouse click) The city of Boston, as seen from above.

Feel free to insert pictures of your own city or town.
NOTE: This analogy requires a slight shifting of our mental model. We are comparing our location in a city to our solar system’s location in the Milky Way galaxy. This is a perspective issue, unrelated to the scale model we have already created.



Optional Slide "A view from within, #2"

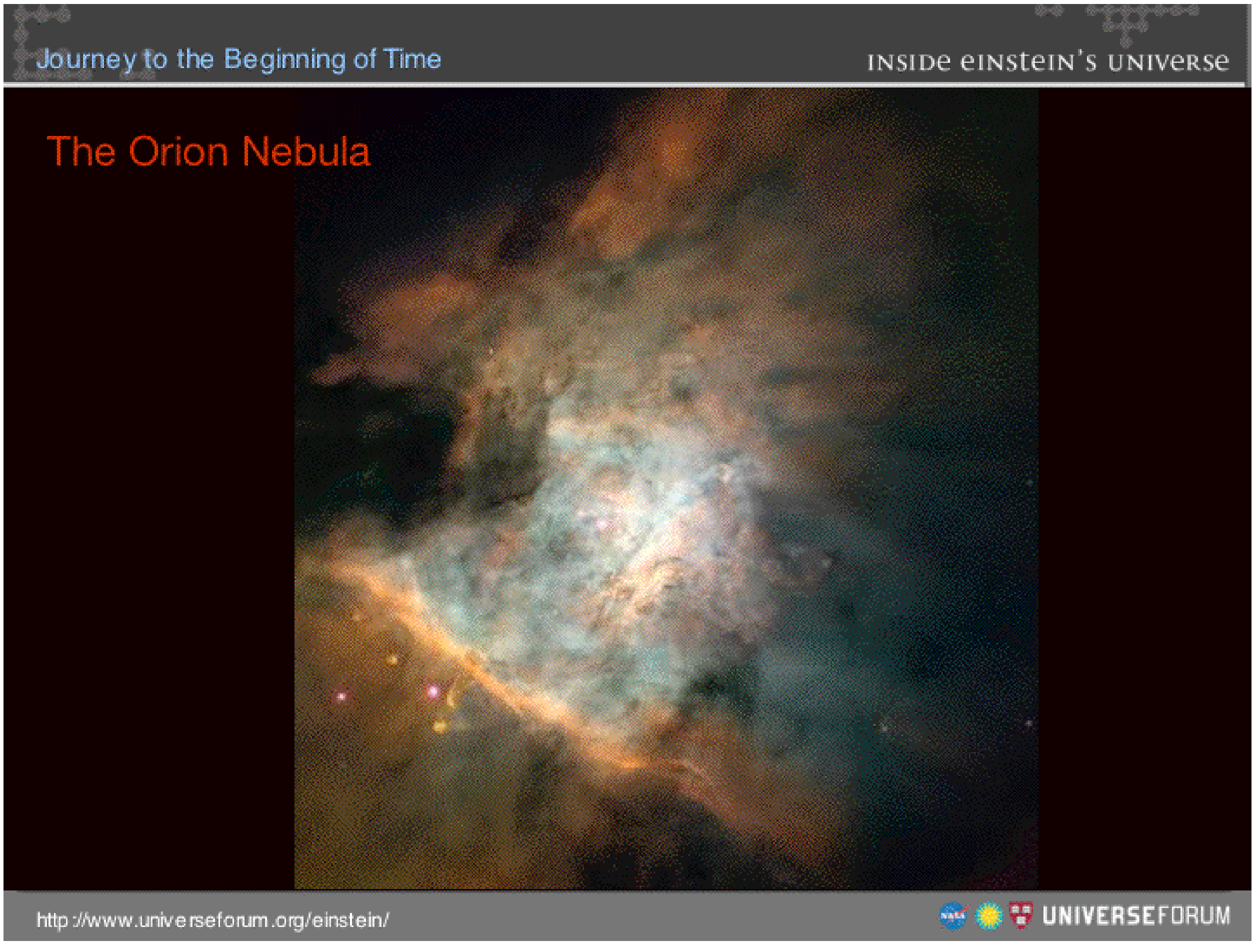
This is our view of the Milky Way Galaxy from the inside.
(Mouse click) This is what our Milky Way Galaxy would look like from "above."
NOTE: The image in the upper right corner is NOT an image of our galaxy. It is an image of another galaxy (one that we CAN view from outside) that looks very similar to our Milky Way.



If the solar system were the size of a cookie and the whole galaxy were the size of North America, the stars in handle of the Big Dipper would be about 2 miles away from our Sun.

Note: other stars within the Big Dipper are at different distances

Image Credit: © 1985 by T. Schulder

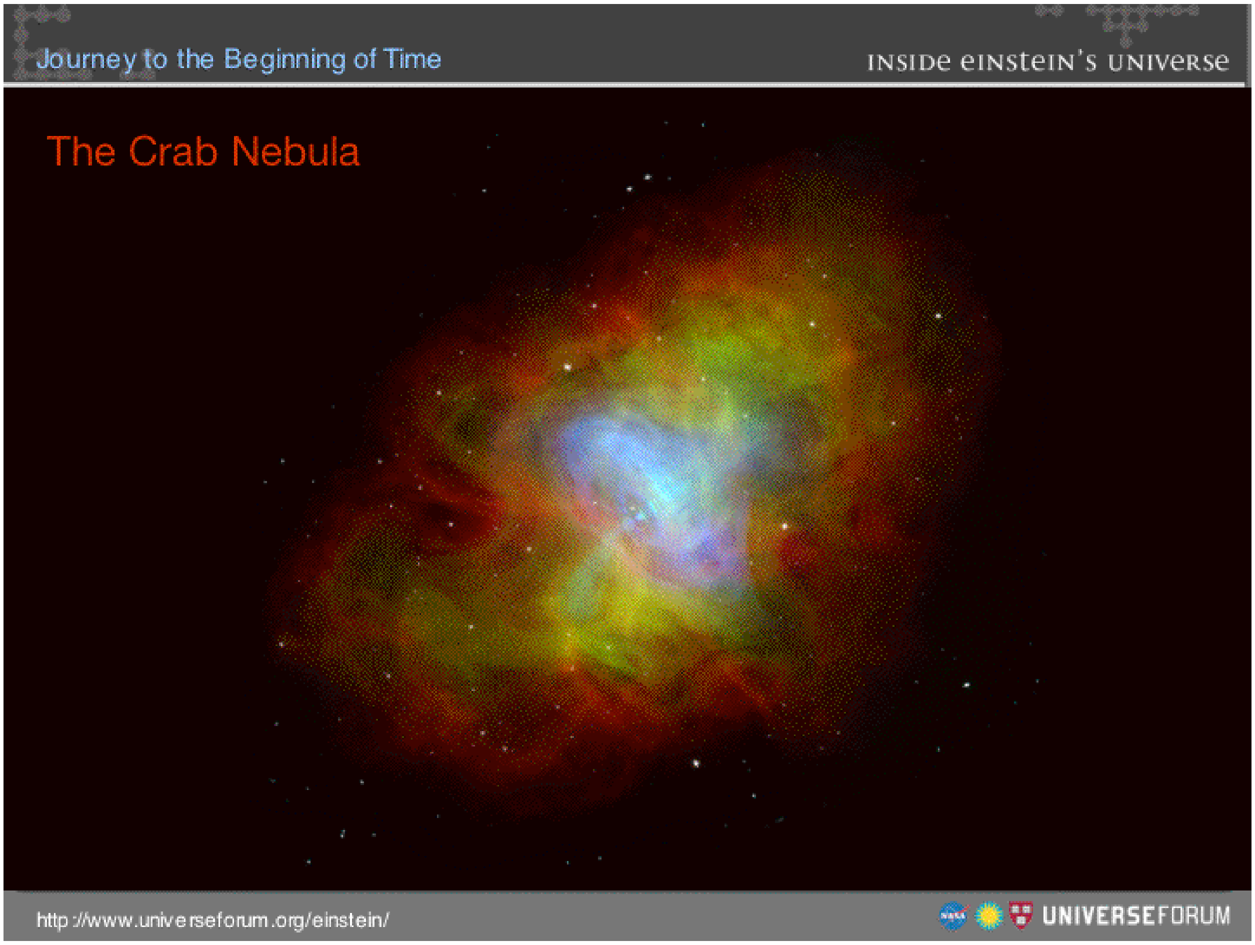


If the solar system were the size of a cookie and the whole galaxy were the size of North America, the Orion Nebula would be roughly the size of a shopping mall (three quarters of a mile across) about 40 miles away from our Sun.

Image credit: *NASA, C.R. O'Dell and S.K. Wong (Rice University)*

If the solar system were the size of a cookie and the whole galaxy were the size of North America, the Pleiades Star Cluster would be approximately one third of a mile across and ten miles away from our Solar System.

Image credit: *NASA, ESA and AURA/Caltech*

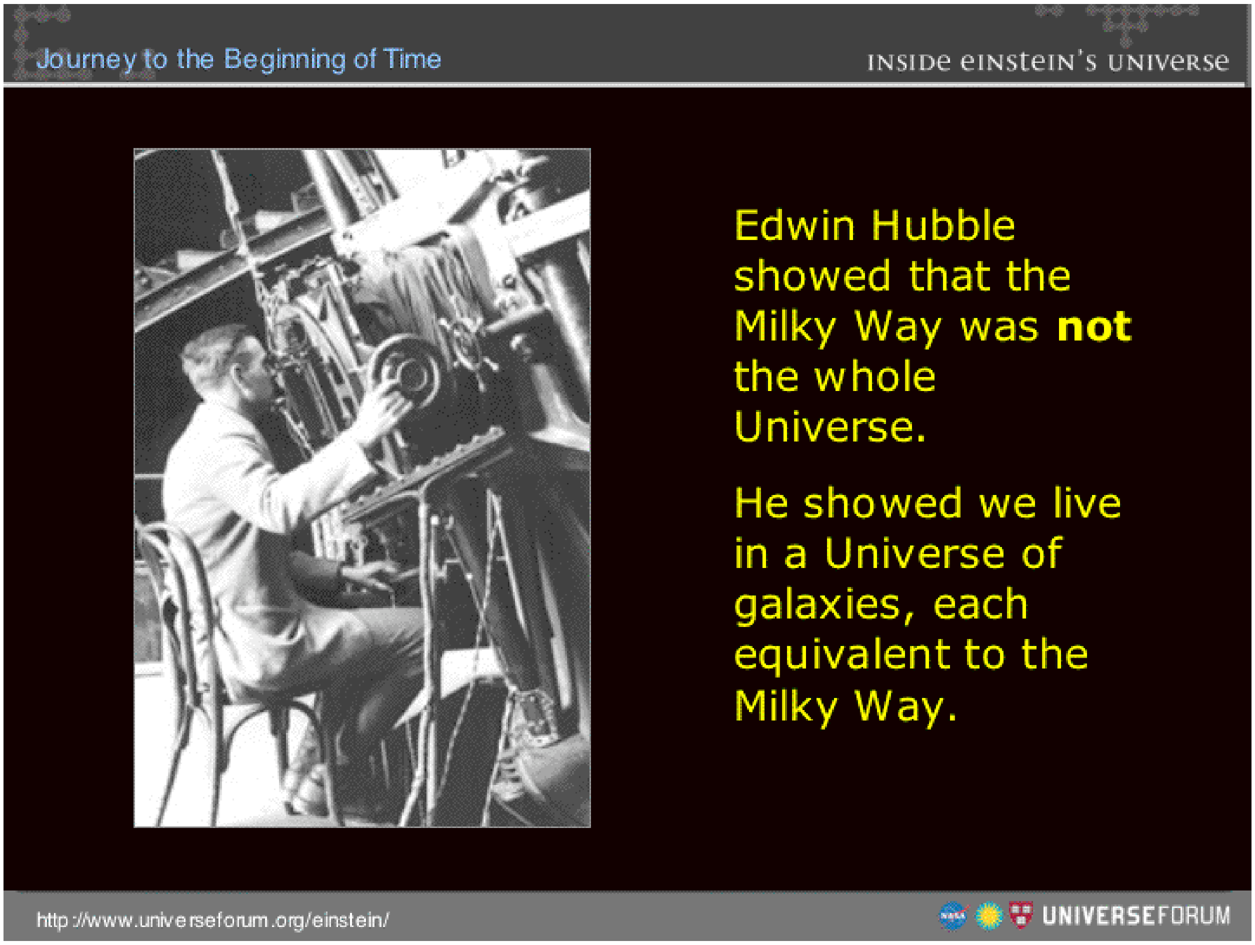


If the solar system were the size of a cookie and the whole galaxy were the size of North America, the Crab Nebula would be approximately one quarter of a mile across and 160 miles away from our Solar System.
The Crab Nebula is the remains of an exploded star that was once 8-12 times the mass of our Sun. Very massive stars end their lives in a gigantic explosion, known as a supernova. This explosion was observed as a bright spot in the sky by people all over the globe in 1054 AD.

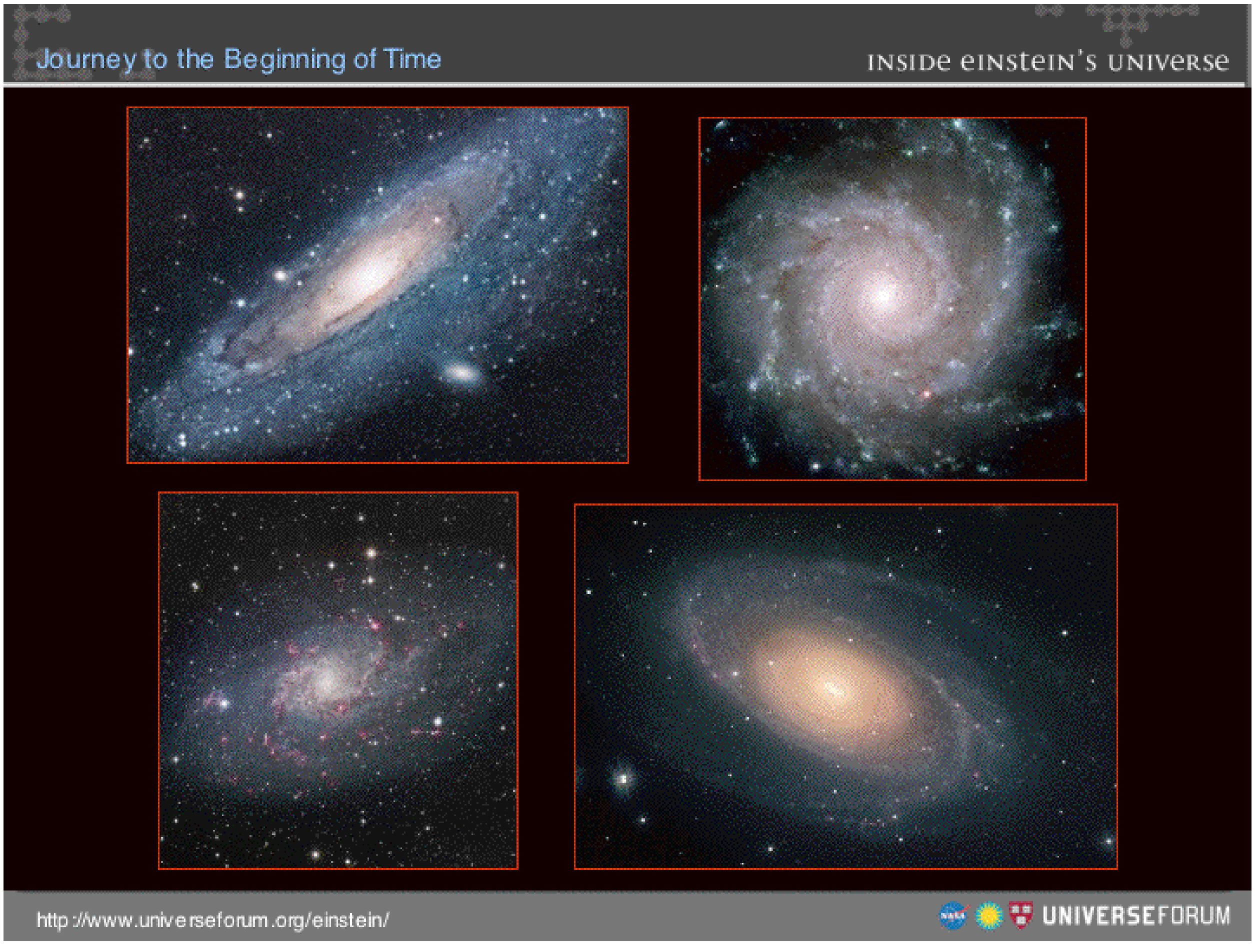
This image is a multi-wavelength composite; three views of this nebula in different wavelengths were pieced together to create this portrait. The images taken in optical (visible) and radio light show a cloud of gaseous filaments. The x-ray image at the center shows very high-energy (extremely hot) spinning around the core of the collapsed star. This spinning star is called a pulsar and spins around about 30 times a second. The material at the core of the pulsar has been compressed into a volume no larger than that of Manhattan Island, and its supporting bedrock! A mere thimbleful of this star-stuff would contain the same mass as about 10 million full sized, African elephants. On the scale of our North America-sized Milky Way, the central pulsar would be smaller than an atom!

Credits: X-ray: NASA/CXC/ASU/J. Hester et al.; Optical: NASA/HST/ASU/J. Hester et al.; Radio: VLA/NRAO

In Einstein's day,the Milky Way galaxy was thought to be the entire universe. Everything we could observe, according to astronomers (and Einstein too!), was contained within the Milky Way. This is not to say that they could not see other galaxies; they simply thought they were 'spiral nebulae' within the Milky Way. These 'spiral nebulae' were supposedly similar to objects such as the Orion Nebula or the Crab Nebula, but with some known mechanism that gave them their spiral shape.



In 1923, Edwin Hubble offered conclusive evidence that the spirals in the sky were in fact other more distant galaxies outside our own. Galaxies are the building blocks of the universe!
Slide credit: R. Kirshner, CfA

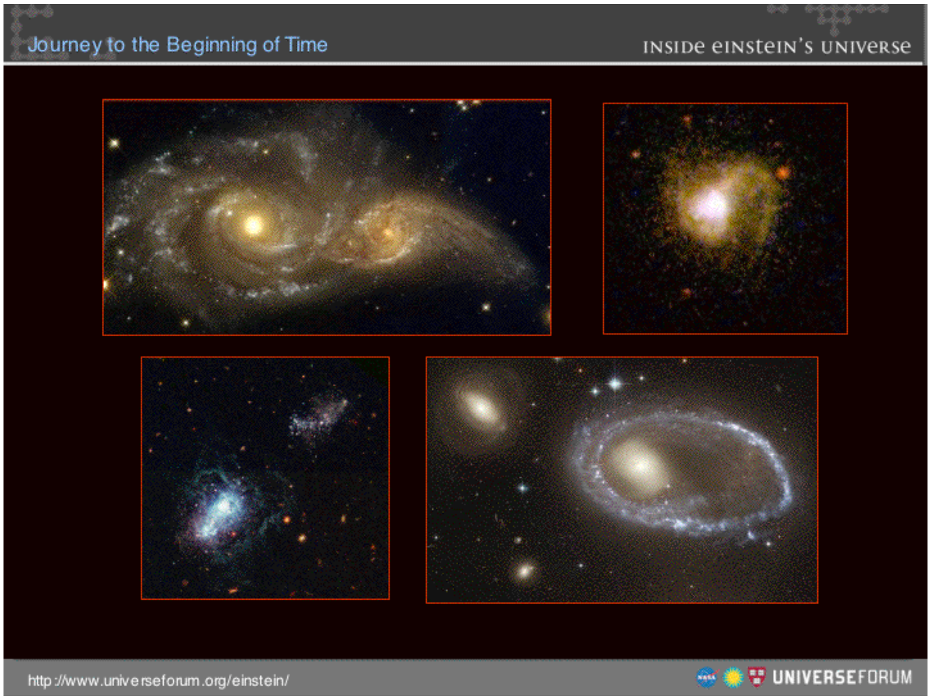


The galaxies in the Universe are much closer together than stars are!
Images Courtesy: STScI, NASA, Gemini Observatory - GMOS Commissioning Team

Imagine: A universe filled with galaxies, each one the size of a CD.
Question: How far out do the galaxies go?
Answer: That's a very good question! If all the galaxies we have ever observed were CDs, they would be scattered around out to ten miles away from our Milky Way. However, there might be more CDs beyond the CDs we observe. We don't know how big the entire universe is, just our part of it. We call the part of the universe that we can observe "the observable universe."

This is the Galaxies Slide

The next series of slides explores the idea of "the observable universe." Why can we only see so far?



The Evolution of Galaxies
Images courtesy: STScI and NASA

Upper left: Colliding galaxies. Earlier in the universe's history, galaxies were much closer together and interacted much more frequently. Because the stars within galaxies are so spread out (remember: if each star were the size of a sugar grain, there would be 2 football fields between typical stars in a galaxy's disk!) stellar collisions are rare. The dramatic distortions seen in images of colliding galaxies are the result of gas and dust interacting.
Learn more: http://hubblesite.org/newscenter/newsdesk/archive/releases/2004/45/
Image Credit: NASA, *ESA, D. Merritt (Rochester Institute of Technology), M. Milosavljevic (Caltech), M. Favata (Cornell), S.A. Hughes (MIT), and D.E. Holz (Univ. of Chicago)*

Upper right: A tiny newborn galaxy POX 186
This is a "late-blooming" galaxy, a small, distorted system of gas and stars that still appears to be in the process of development, even though most of its galactic cousins are believed to have started forming billions of years ago. Evidence of the galaxy's youthfulness can be seen in the burst of newborn stars and its disturbed shape. This evidence indicates that the galaxy, called POX 186, formed when two smaller clumps of gas and stars collided less than 100 million years ago (a relatively recent event in the universe's 13-billion-year history), triggering more star formation. Most large galaxies, such as our Milky Way, are thought to have formed the bulk of their stars billions of years ago.
Learn more: http://hubblesite.org/newscenter/newsdesk/archive/releases/2002/16/
Image Credit: *NASA and Michael Corbin (CSC/STScI)*

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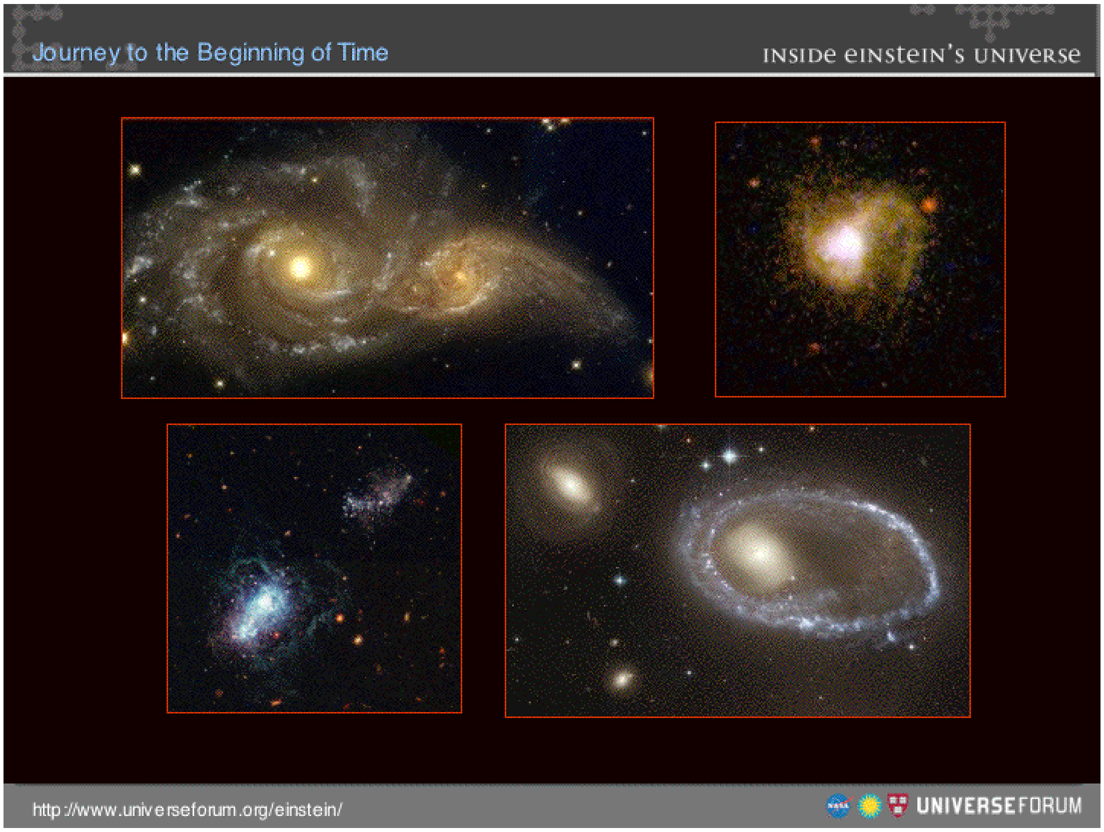


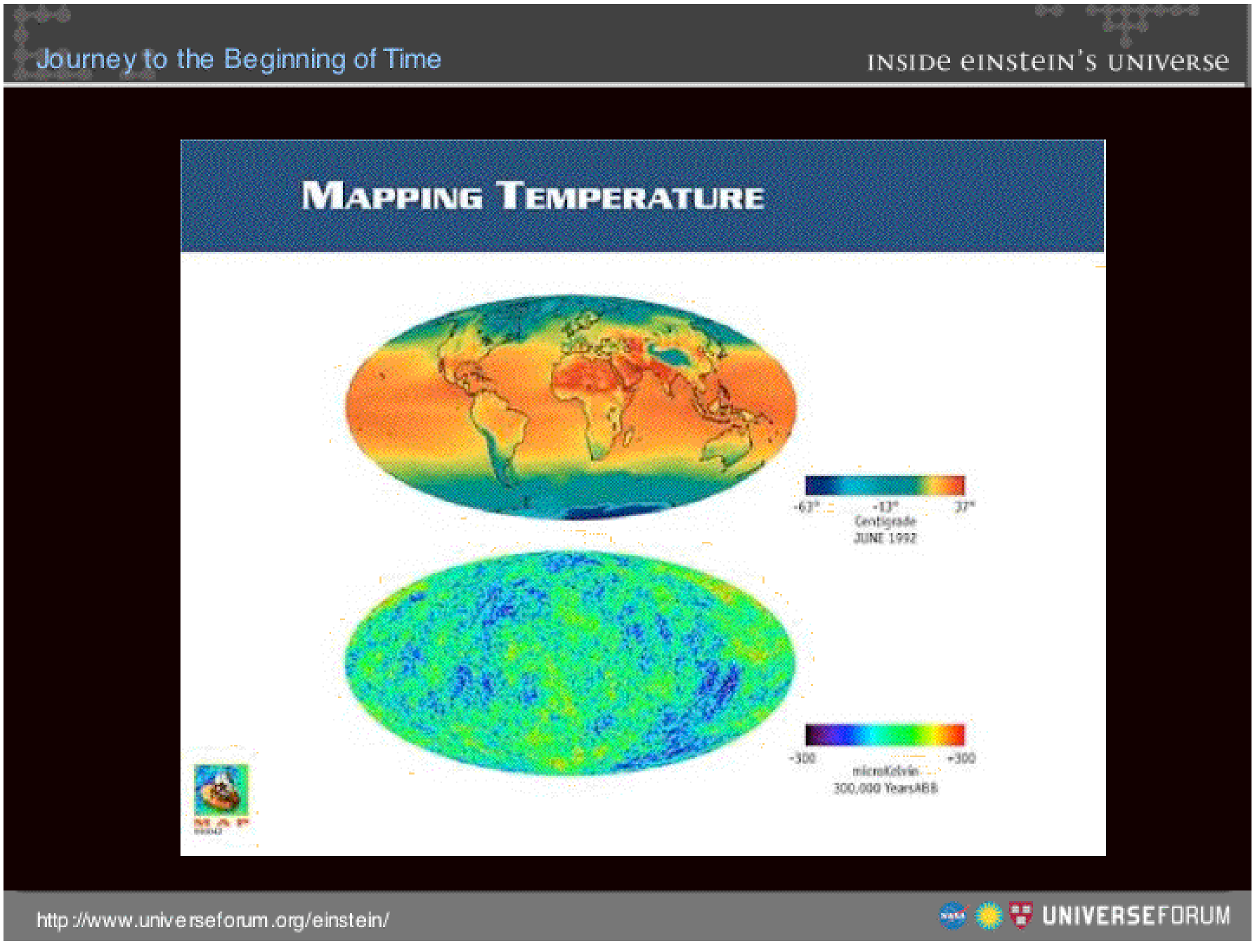
The Evolution of Galaxies
Images courtesy: STScI and NASA

Lower left: I Zwicky 18, the youngest known galaxy. According to Hubble Space Telescope data, the stars in this galaxy formed roughly 500 million years ago. It should by noted, though not necessarily to the audience, that this galaxy is actually very nearby, 45 million light year away. Astronomers believe it resembles other very young galaxies and are trying to figure out how such a young-looking galaxy can exist in a 'mature' universe.
Learn more: http://hubblesite.org/newscenter/newsdesk/archive/releases/2004/35/image/a
Image Credit: *NASA, ESA, Y. Izotov (Main Astronomical Observatory, Kyiv, UA) and T. Thuan (University of Virginia)*

Lower right: A galaxy recently disturbed by a collision with a smaller galaxy (not the smaller galaxy in this image - the culprit is located outside the field of view of this image).
Learn more: http://hubblesite.org/newscenter/newsdesk/archive/releases/2004/15/
Image Credit: *NASA, ESA, and The Hubble Heritage Team (AURA/STScI)*

Scientific Visualization: Fly-through the Hubble Ultra Deep Field
Animation Credit: *NASA, ESA, F. Summers, Z. Levay, L. Frattare, B. Mobasher, A. Koekemoer and the HUDF Team (STScI)*

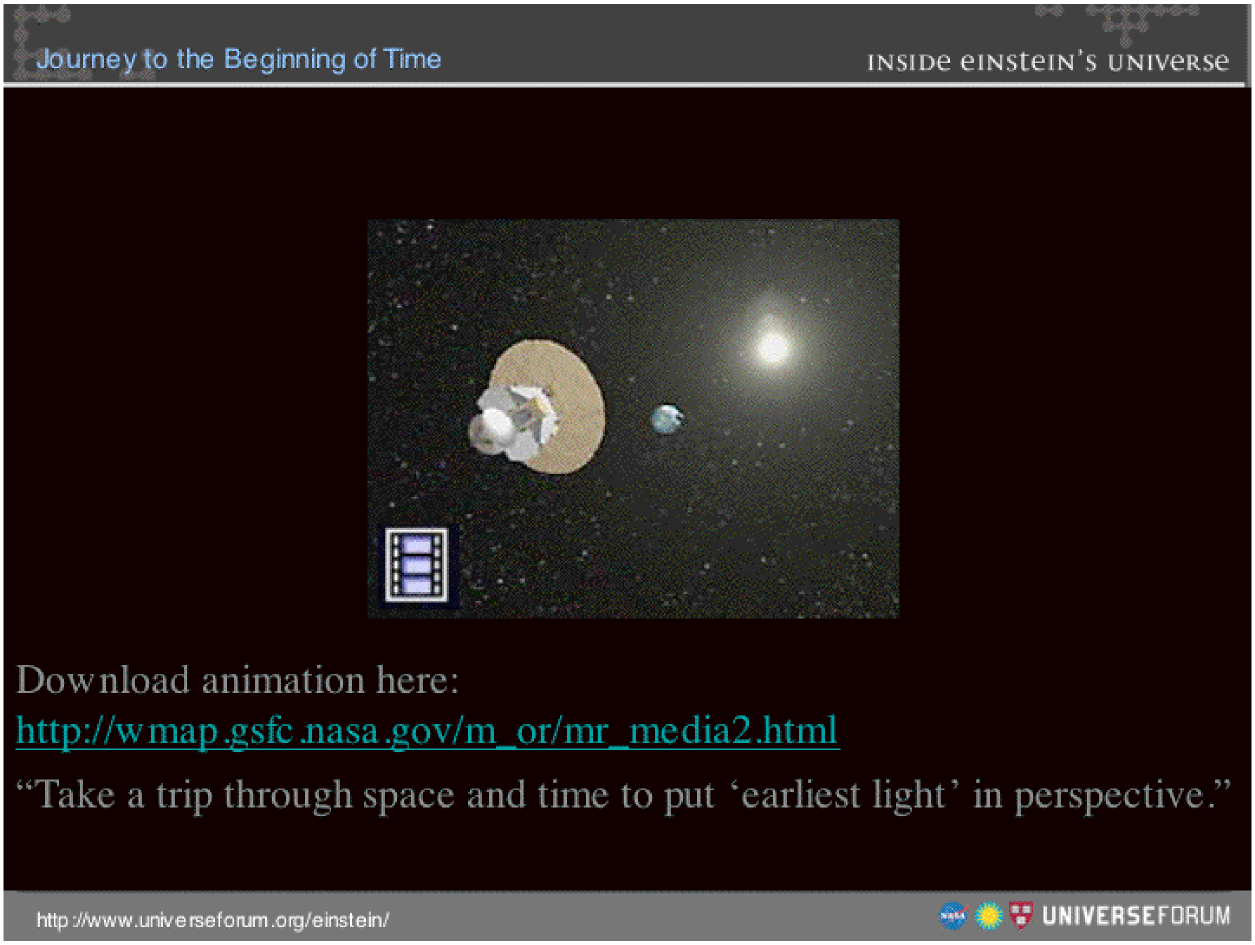
A flight through the Hubble Ultra Deep Field, the most distant visible-light view of the universe. The redshifts of 5,333 galaxies were converted to distances to assemble a 3-D model of the data. This scientific visualization flies through the data to showcase its true 3-D nature. Because looking out in space is looking back in time, this journey from near to far is also a journey into the past. We see galaxies as they looked billions of years ago when light from their stars first began their journey.



Optional Slide - Temperature Maps
Image Credit: WMAP

How do we create a two-dimensional map of a sphere? Imagine sitting in the Earth's core, looking out at the continents floating on the surface. Mapping the three dimensional sphere onto two dimensional paper produces the oval shape we see above This representation, called an Aitoff projection, is something many students have seen in textbook maps. The colors in the top image represent different temperatures on the Earth's surface.

Astronomers create a similar image of the sky around us. By projecting the sphere of the sky onto paper, we see a similar oval shape. Again, the colors represent temperature, in this case, the temperature of the light detected by the WMAP space craft. WMAP views the sky with microwave eyes - the colors represent a range of temperatures of very low energy. This low energy light is all around us, leftover from the Big Bang.



This animation illustrates the big idea of "Journey to the Beginning of Time." As we simulate a trip through space, we see the images of objects in the universe as they appeared when the light first left them to travel across space to reach our detectors. Note that the images in this animation are simulated from telescopic observations, but are not represent actual photographs.

We begin at the Wilkinson Microwave Anisotropy Probe (WMAP) orbiting one million miles above the Earth, and travel outward through our solar system, into our local stellar neighborhood, and then around the disk of our Milky Way galaxy. As we leave the Milky Way, we find ourselves in a universe filled with billions of galaxies. Because the light from distant galaxies takes vast amounts of time to reach our telescopes here on Earth, we see these galaxies as they looked in the past, when the universe was very turbulent. Finally, looking back as far as we can see, we detect the afterglow of the Big Bang era. This light has taken over 13 billion years to reach the WMAP satellite from its origin in the infant universe, and in that time, the seeds of matter have evolved into the universe of galaxies, stars and planets that we see today.

One misconception that this animation can generate is that flying away from Earth will allow us to travel back in time. Remember that the light we observe has already been traveling for many years, so the objects the light came from have been evolving over that time. If we could observe those distant galaxies as they are today, they probably look very similar to nearby galaxies (which we view today at a much later point in the universe's history). If we were to fly out to those distant galaxies we would have to travel for many billions of years, and those galaxies would continue to evolve. We would therefore see them as they would look many billions of years later, as far into the future as the signal from the past has taken to reach us today. Of course, we do not have the technology to do this, but it is fun to imagine.