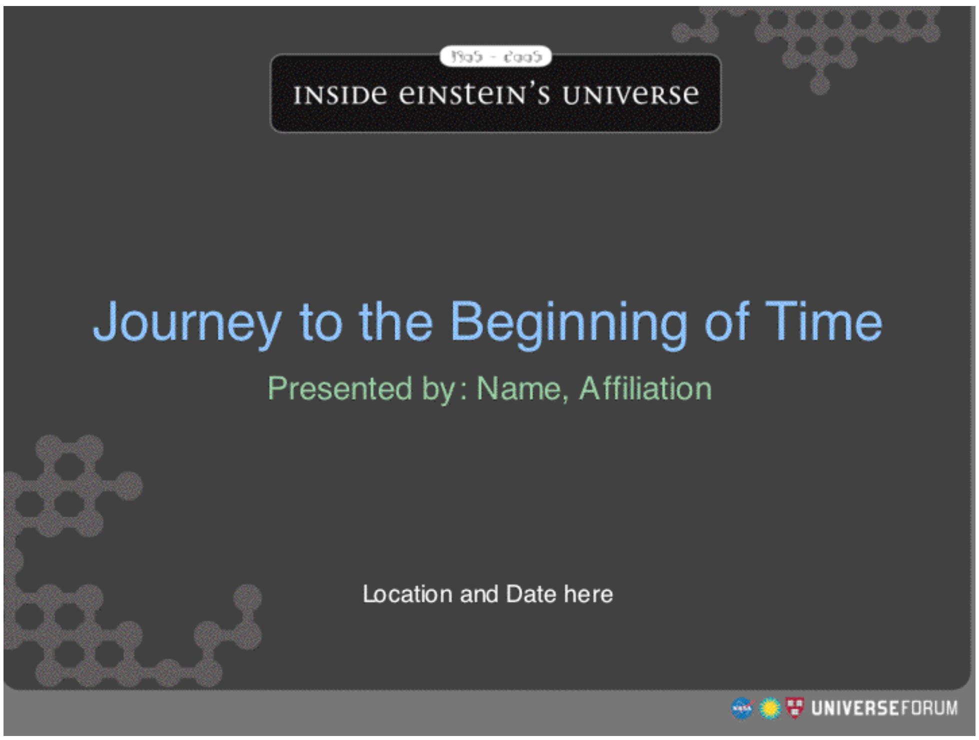
1905 - 2005
INSIDE EINSTEIN'S UNIVERSE

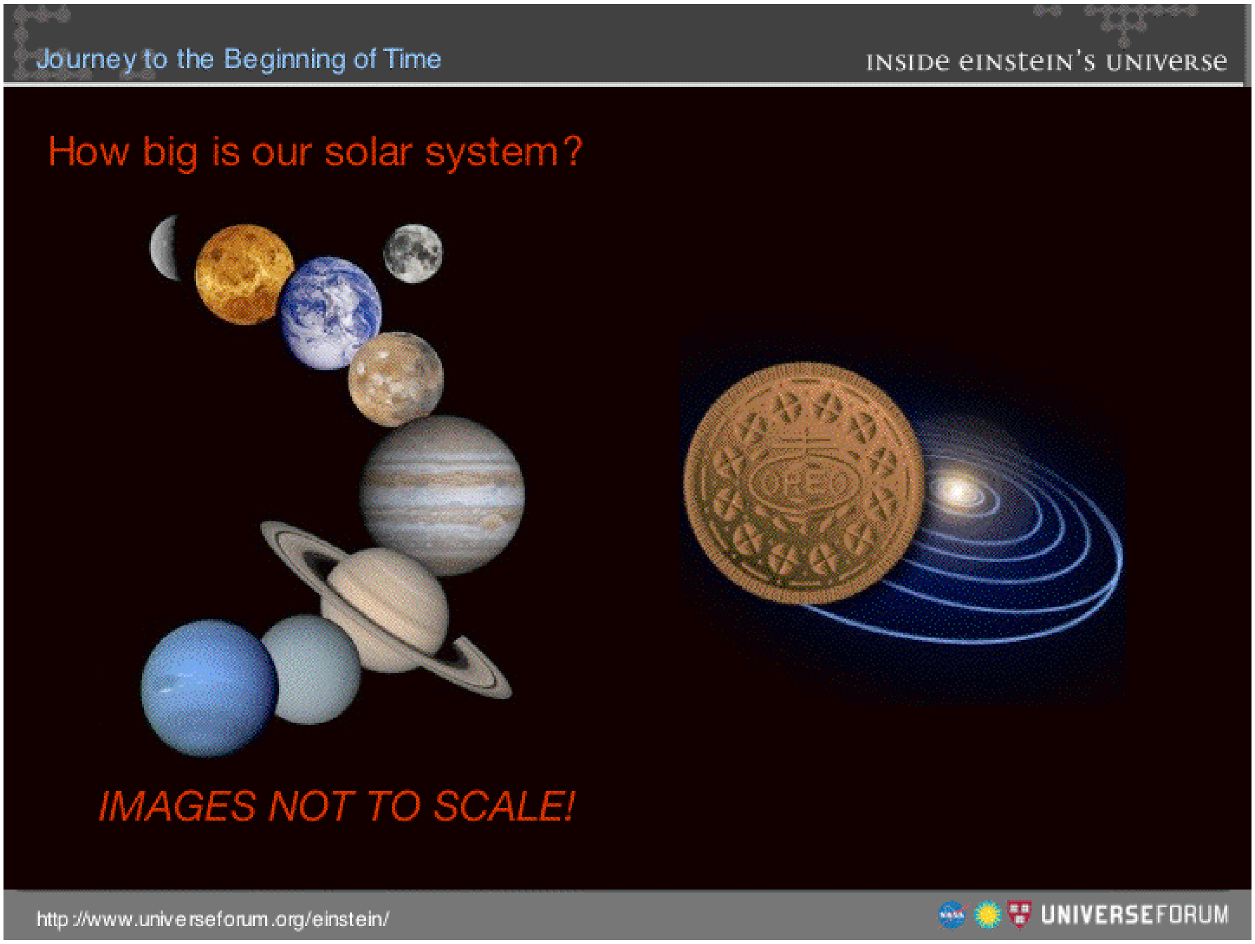
This document was created for people who do not have access to Power Point. It contains screen shots of the images and notes in the main “Journey to the Beginning of Time” presentation. Though we cannot supply you with all of the included images, this document should give you an idea of the images used 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 the universe looked like in the past.

This Power Point presentation contains the suggested Visual Resources to accompany the “Inside Einstein’s Universe” demonstration “Journey to the Beginning of Time.” Each image slide contains notes and content information. For a detailed description of the demonstration, please see the script. Because Power Point presentations require the source file for animations to be saved in the same folder as the presentation itself, links are given where animations can be downloaded from the web. If you do not see an animation, please visit the appropriate web site.

This is the Title Slide. You can customize the text by double clicking on it.



Step 1 – Our Solar System
Solar System Mosaic: NASA/JPL/Caltech
Oreo cookie: used without permission

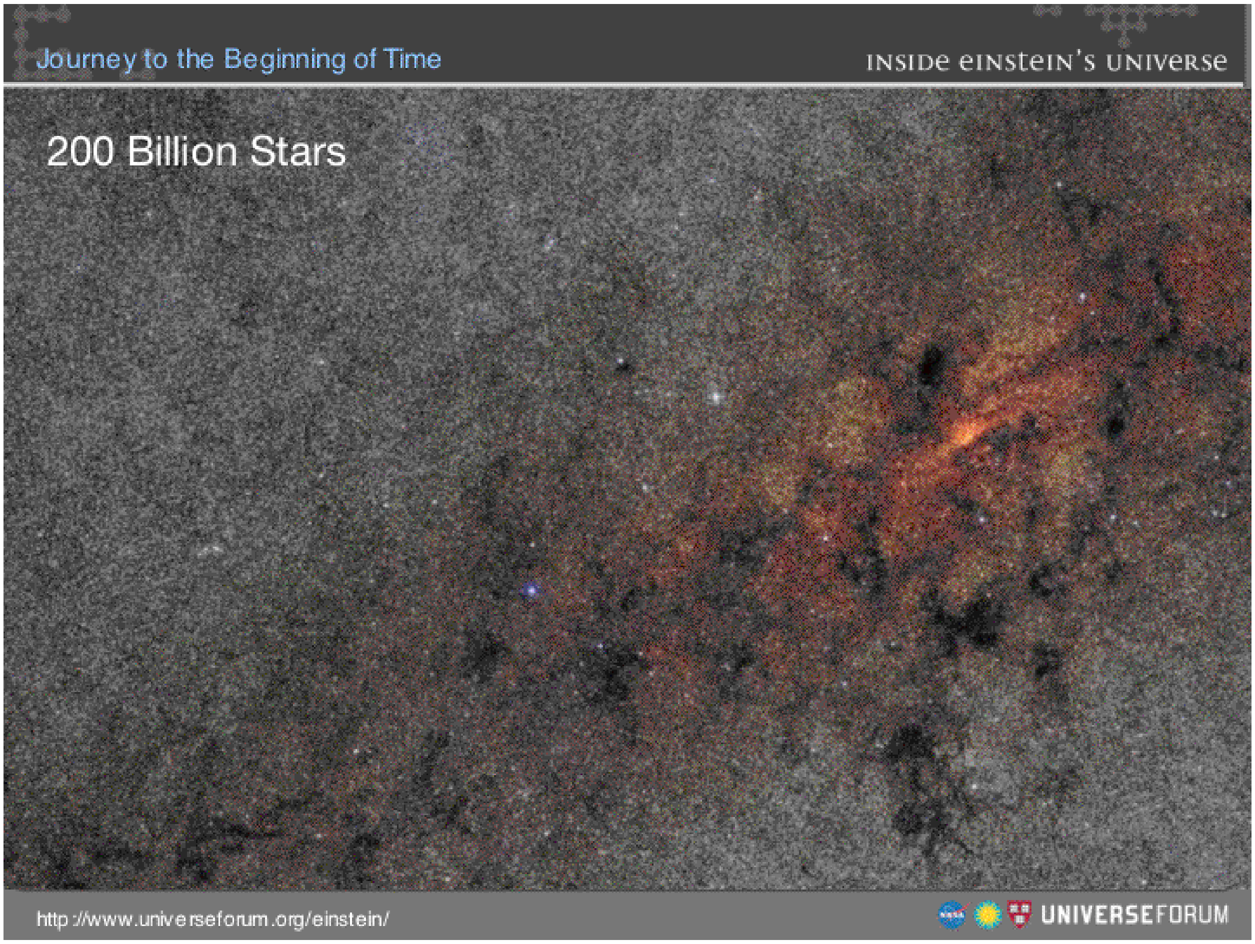
Ask your audience to imagine shrinking the entire solar system, from the Sun all the way out to Pluto, down to the size of a round sandwich cookie. Remind your audience that even on this scale, the Sun itself is a microscopic speck of sugar in the center of the cookie. Pluto, then, is an even tinier speck rolling around the outside edge of the cookie. If you like, you can call up a volunteer to “be” the solar system, holding the cookie at one end of the room.

Step 2 – The Next Nearest Star
Suggested Visual: a solar system, a cookie, and a football field

Now ask your audience the following question: on this scale (solar system = one cookie, approximately two inches) how far away is the next nearest star? If you like, you can invite another volunteer to become our Solar System's nearest neighbor by holding a second cookie and standing the correct distance away. Let your audience guess how far away the second cookie should be. As it turns out, the next closest star to our Sun is approximately two football fields away! Your second volunteer may not be able to model this distance in your demonstration. As consolation, though, you do have a cookie to spare.

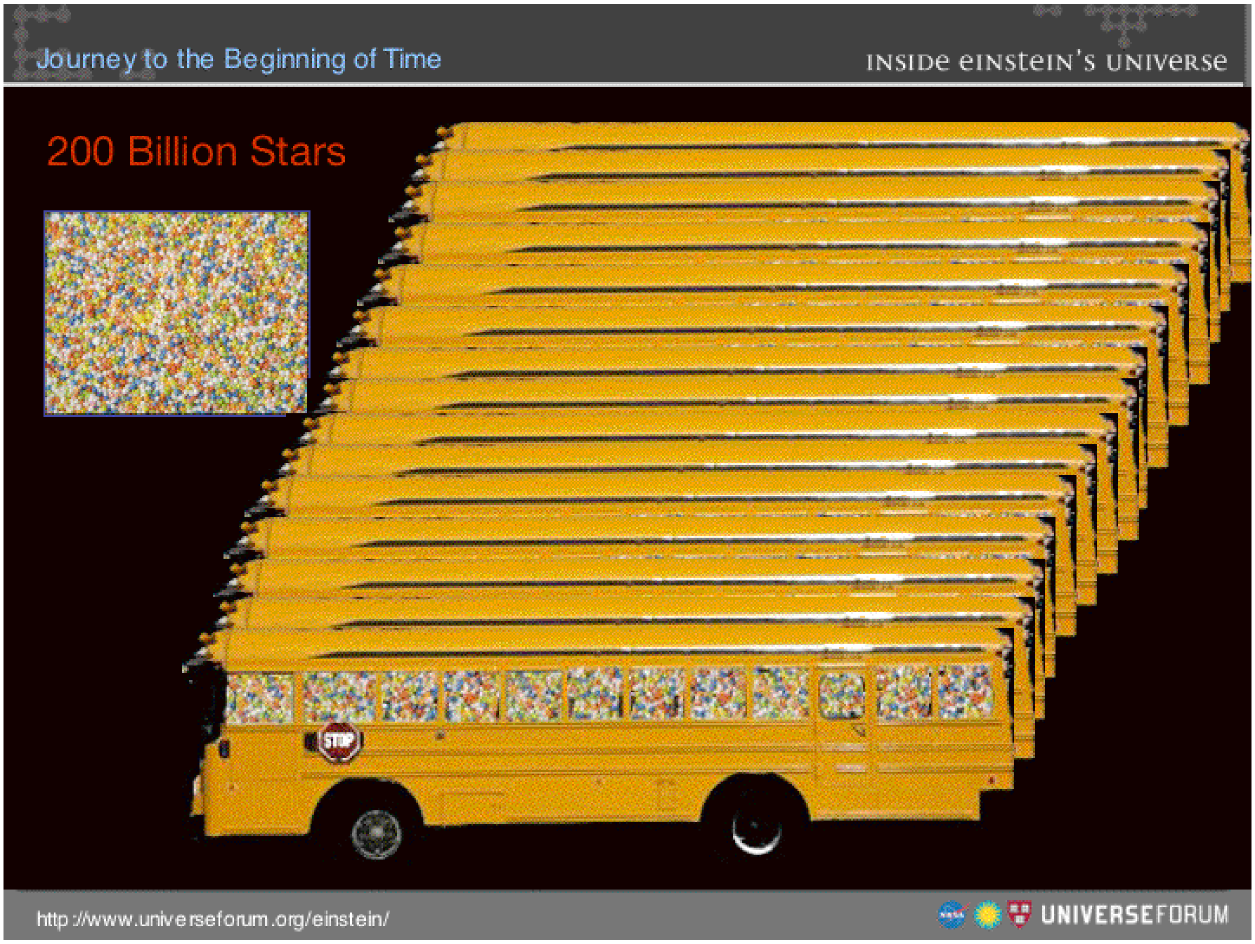
NOTE: Insert your own favorite stadium here.

The bright yellow star in this star field is Alpha Centauri.



Step 3 – All the Stars in our Galaxy
Suggested Visual: A view of stars toward the center of our galaxy
Image Credit: **2MASS/G. Kopan, R. Hurt**

It is now time to imagine the even bigger picture…our Sun (and the neighboring stars outside our Solar System) is just one part of the entire Milky Way galaxy. In order to imagine the entire Milky Way galaxy, we need to think in terms of stars. We will pretend that the microscopic speck at the center of the cookies are actually a tiny grains of sugar – cake-decorating sprinkles. How many cake-decorating sprinkles are in our entire galaxy? Astronomers have determined that there are anywhere from 200 billion to 400 billion stars in our galaxy. They estimate that 7% (about 14 billion) of those stars are like our Sun.



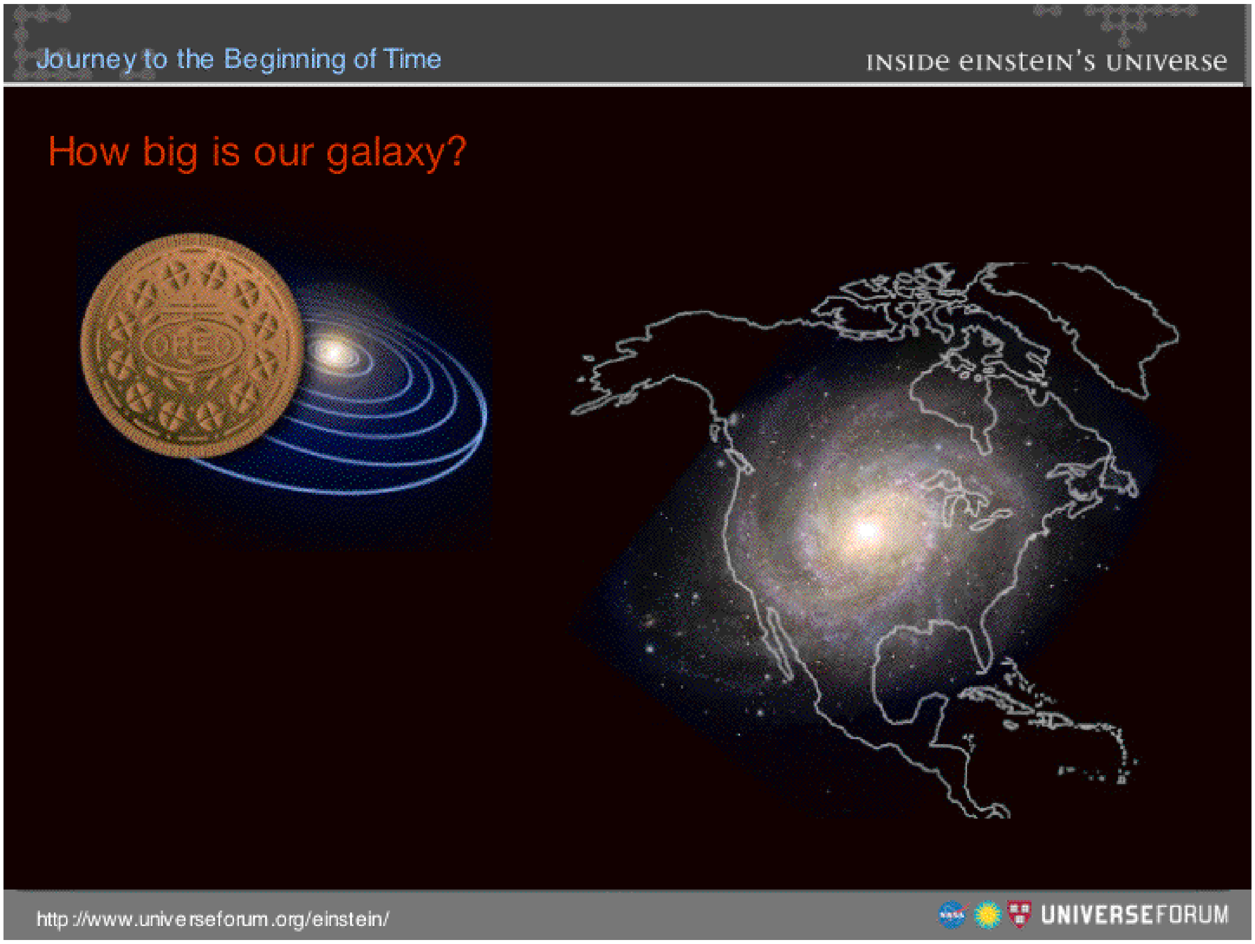
Step 4 – 200 Billion Stars
Suggested Visual: Sprinkles and a school bus

Invite volunteers from your audience up to the stage to pour sprinkles into a clear container. (We suggest a large bottle, such as that found at a water cooler. You will not need to fill it all the way, just enough to realize how long it takes to create a substantial pile.) Ask them how close they think they are to 200 billion. A large water bottle or two will seem to many like a reasonable approximation for that many sprinkles. Now reveal that it would take 15 standard-size school buses filled with sprinkles to represent 200 billion stars.

Step 5 – The Milky Way Galaxy
Suggested Visual: Cookie, school bus, and perspective on North America

We now have fifteen school buses stuffed with sprinkles. What do we do with them? Where do we put all the sprinkles? If each star is the size of a sprinkle…and each solar system the size of a cookie…the entire Milky Way galaxy will be the size of North America, a very flat disc 2500 miles across and 25 miles deep! About one third of the sprinkles need to go into the middle of the galaxy. Take five of your school buses and drive them off to Kansas for unloading. The rest of the stars need to spread out all across the continent. Remember that stars in the disc are approximately two football fields apart. This means that as you are driving around the continent, you need to drop off one star every tenth of a mile you drive. Get ready for a long trip!

Our own sprinkle (and its surrounding cookie) would be about 10 miles off the ground, floating above Buffalo, New York. It takes light one hundred thousand years to travel from one side of our Galaxy to the other. On the scale of our model, that's 100,000 years just to get from one side of North America to the other!



Step 5 – The Milky Way Galaxy
Suggested Visual: A picture of a spiral galaxy superimposed over a picture of North America

Our solar system is to out Milky Way Galaxy as a cookie is to North America.

Step 6 – The Milky Way Galaxy
Suggested Visual: A spiral galaxy and a CD

Remind your audience about the cosmic speed limit. It takes 100 thousand years for light to travel across a single spiral galaxy. In our previous model, one spiral galaxy was the size of a continent. If we are going to build a universe filled with galaxies, we are going to have to shrink this continent down into something much smaller. Put on your shrinking caps and let's go!

A galaxy is about one hundred times wider than it is thick. A good approximation of this ratio is a compact disc. So let's take the entire continent of North America and shrink it down to the size of a CD. Coincidentally enough, you just happen to have a CD with you. This CD is now our Milky Way Galaxy! Is there a volunteer who would like to be the Milky Way galaxy?

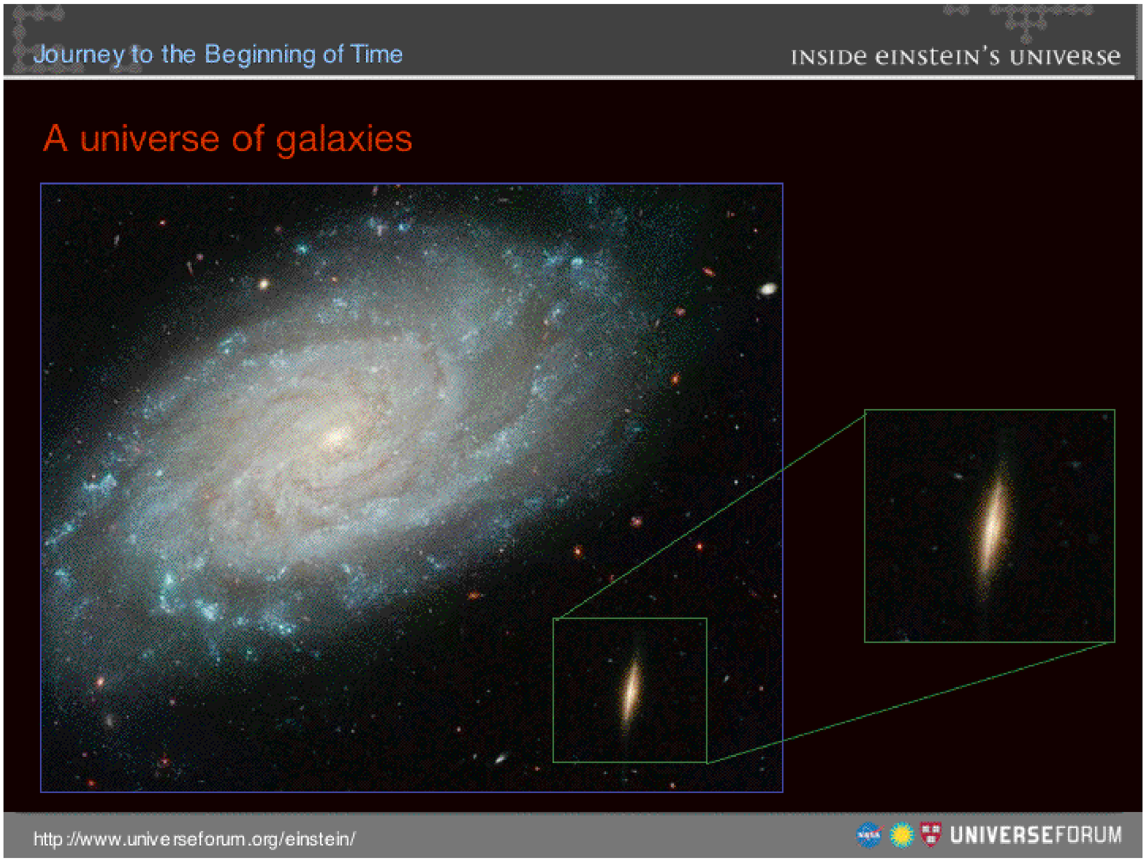
Remember that light takes one hundred thousand years to travel across the entire galaxy. A CD may seem small, but even on Einstein's hypothetical beam of light, it takes a long time to cross it.

Step 7 – The Andromeda Galaxy
Suggested Visual: The Andromeda Galaxy (and a CD)

A second volunteer can be the nearest spiral galaxy to the Milky Way, the Andromeda Galaxy. How far away does the audience think the Andromeda Galaxy is from the Milky Way? After their experience with stars within the galaxy, many audience members will try to send your second volunteer to another city!

Surprisingly enough, the answer is eight feet, or approximately 20 CD diameters away. Galaxies are much closer together than stars, relative to their size. Do not be fooled, however; it is still very difficult to travel between them. You can ask another volunteer to be a photon of light traveling between the two galaxies, but it will take him or her 2 million years to travel that distance. At this scale (1 galaxy = 12 cm) light takes 1 million years to travel 4 feet. What was happening on Earth 2 million years ago, when the light from the Andromeda Galaxy began its journey to our eyes?

Galaxies are the building blocks of our universe. The farther out we look, the more galaxies we see.

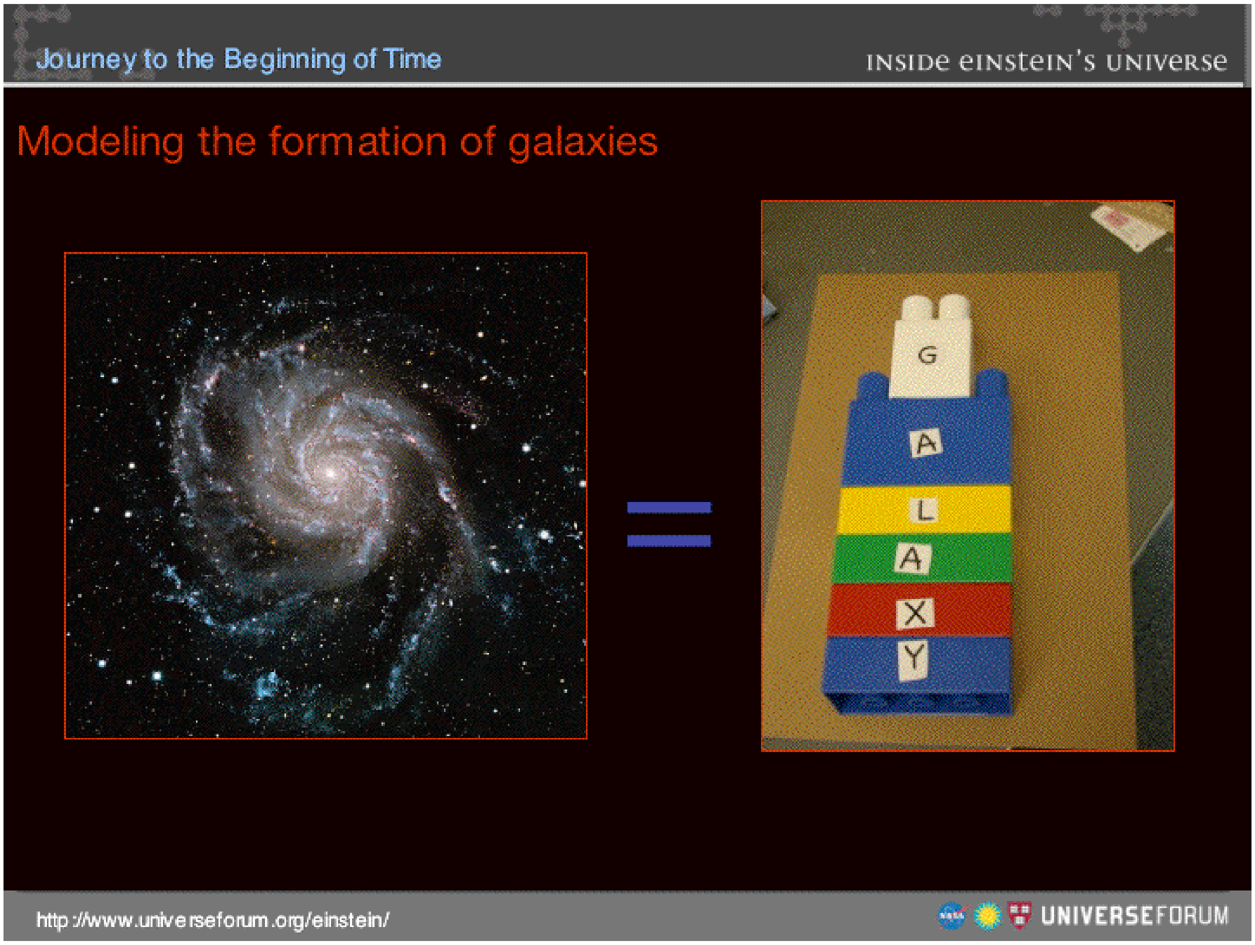


Step 9 – Distant Galaxies
Suggested Visual: Image of a spiral galaxy with a more distant galaxy in the same field. A good example is: http://hubblesite.org/newscenter/newsdesk/archive/releases/2003/24/

The large spiral galaxy in this image is about 50 times farther than the Andromeda Galaxy. On the scale of our CD-filled universe, this is about 400 feet from our own Milky Way CD. Your volunteer would have to stand in the parking lot to model this to scale. What about the smaller galaxy in the lower right part of the image? Is this a smaller galaxy at the same distance or a further away galaxy that simply looks smaller? Astronomers assume that most, if not all, spiral galaxies look pretty much the same. Therefore, this smaller-looking galaxy is probably a more distant galaxy. It is about five times as small as the larger-looking galaxy, so it is probably about five times farther…about two third of a mile away, on the scale of CDs! Light traveling from these galaxies takes millions of years to get to our telescopes.

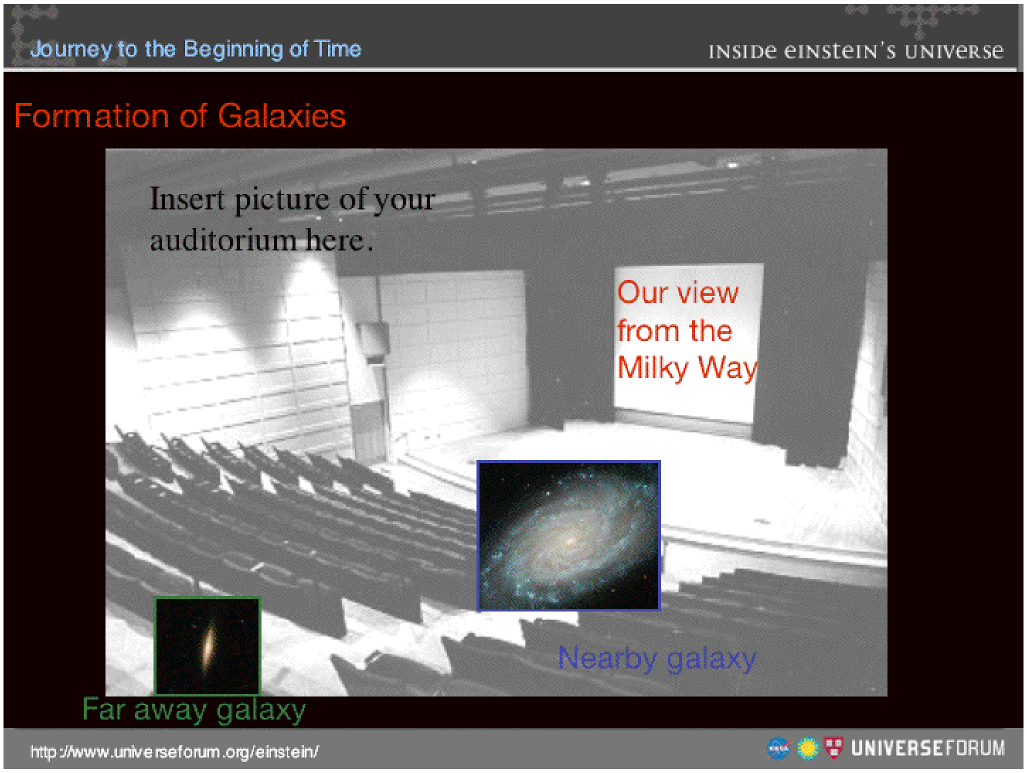
Unfortunately, we don't have the time or the space to show this. Instead we will need to shrink this scale down to use our auditorium, and tag along on the journey through space using our trusty volunteers. Einstein imagined what it would be like to ride on a beam of light; what if we actually become beams of light? What will we learn about the galaxies in our universe?

Credit: *NASA, The Hubble Heritage Team and A. Riess (STScI)*



Step 9 - Light travel time

In this activity, volunteers will model the evolution of galaxies and the idea of "lookback time" We will model the formation of galaxies using building blocks. You may wish to replace the block image on this page with a picture of your own building blocks.



The notes for this slide explain the process of the demonstration. The images contained in this slide are for your information; you may wish to delete this slide from your presentation, as you will be modeling this scenario with your volunteers.

Step 10 – Setting Up

Position your first volunteer at the back/far side of the room with a set of building blocks and photographs. (S)he is the Distant Galaxy. Position your second volunteer (along with the second set of blocks and photographs) about halfway between you (the telescope/observer) and Distant Galaxy. (S)he is Not-So-Distant Galaxy. Make sure there is a straight path between you and both galaxies for your photons to travel.

Explain to your audience that we are going to take pictures of galaxies in the universe. As we just demonstrated, sending a spacecraft to these distant objects would take too long. Luckily, these objects are sending information to us in the form of photons (beams/packets) of light.

Now call up your third and fourth volunteers. These are your 'light messengers' – photons or beams of light traveling across the vast distances of space. They will each carry a message from their source galaxy. When these photons reach our telescopes here on Earth, or just above the Earth in space, we collect the light (their message) and focus it to record an image of what that object looks like. Your volunteer photons are going to carry messages of what their galaxies look like to you.

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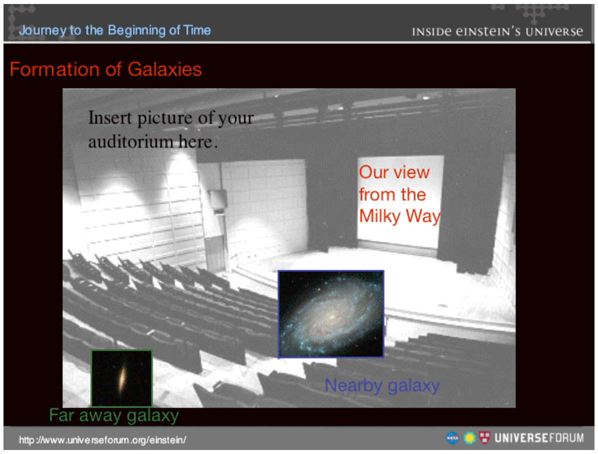


Assign one photon to each galaxy. Remind your audience that there are many photons (or beams) of light coming from each galaxy, but we are interested in these two. These photons need to reach you (the telescope) at the same time. Because Einstein tells us that the speed of light is the same for ALL photons, which photon needs to leave first? [Answer: the Distant Photon]

Step 11 – Forming Galaxies

Cosmic time begins! Your galaxies begin building up their blocks, starting with the block labeled "Y" forming galaxies…Y! Now another block…XY!

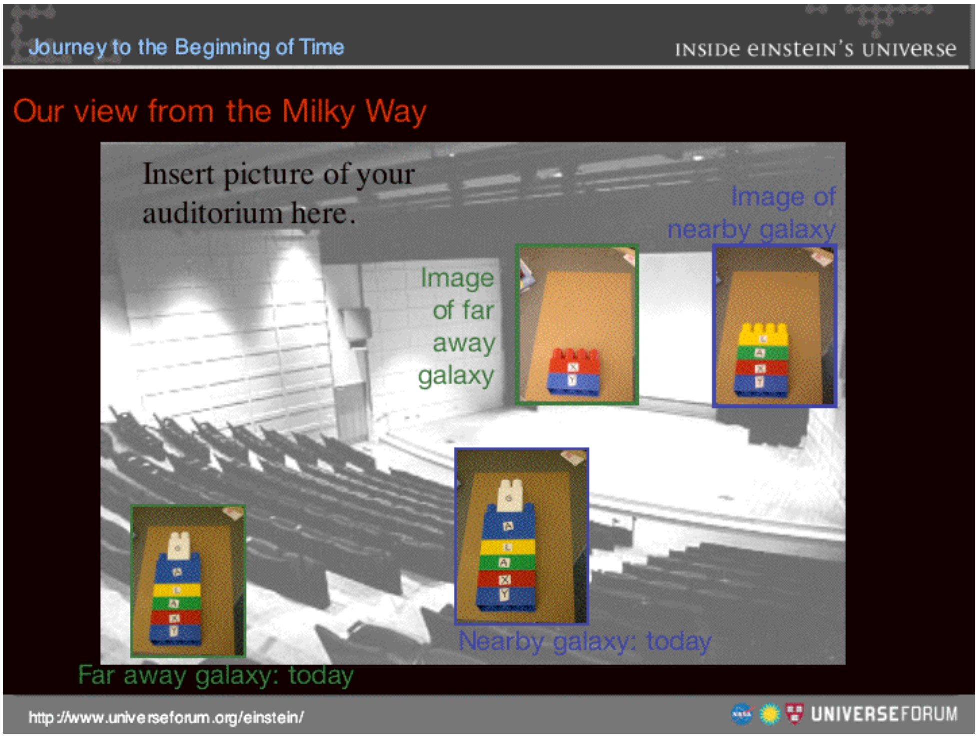
Step 12 – Distant Photon Leaves

Volunteer 3 (Distant Photon) begins its journey, traveling at the speed of light – baby steps please! Remember that light from this galaxy has been shining this whole time, but this particular photon is the one leaving now, taking with it the picture (photograph) of what the galaxy looks like at that moment (XY).
The galaxies continue to form…AXY! LAXY!

Step 13 – The Distant Photon Arrives at the Distance of the Not-So-Distant Galaxy

This galaxy has also been forming and shining since cosmic time began, but we are interested in the photon that is leaving now. Not-So-Distant photon (Volunteer 4), please begin your journey! Don't forget your message of what the galaxy looks like now (LAXY).

Remember photons, you are traveling at the cosmic speed limit. It is taking you millions and millions of years to travel through space. All the while, galaxies are continuing to form…ALAXY…GALAXY.



Again, this slide is for informational purposes only. You may wish to swap it out with a slide containing digital images of the actual blocks you are using to represent the formation of galaxies. "Messages" delivered by your volunteer photons may vary, depending on the exact timing of your presentation.

Step 14 – The Photons Arrive at our Telescopes

Finally, after millions of years the photons are here! Photons, deliver your messages! Tell us what your galaxy looked like when you left:

- Distant Galaxy is only two blocks big (XY).
- Not-So-Distant Galaxy is four blocks big (LAXY)

(If you are using digital versions of the images, you should take this moment to project the two images on your screen. Taking the messages from the photons and "inputting them into your computer" can be a representation of the telescope gathering light and focusing it into an image.)

Now ask your audience, what the galaxies look like today. What would they see if they could travel instantaneously through space? Of course, Einstein tells us that we cannot travel instantaneously, but luckily you have people stationed near each galaxy to tell us what each galaxies looks like today.

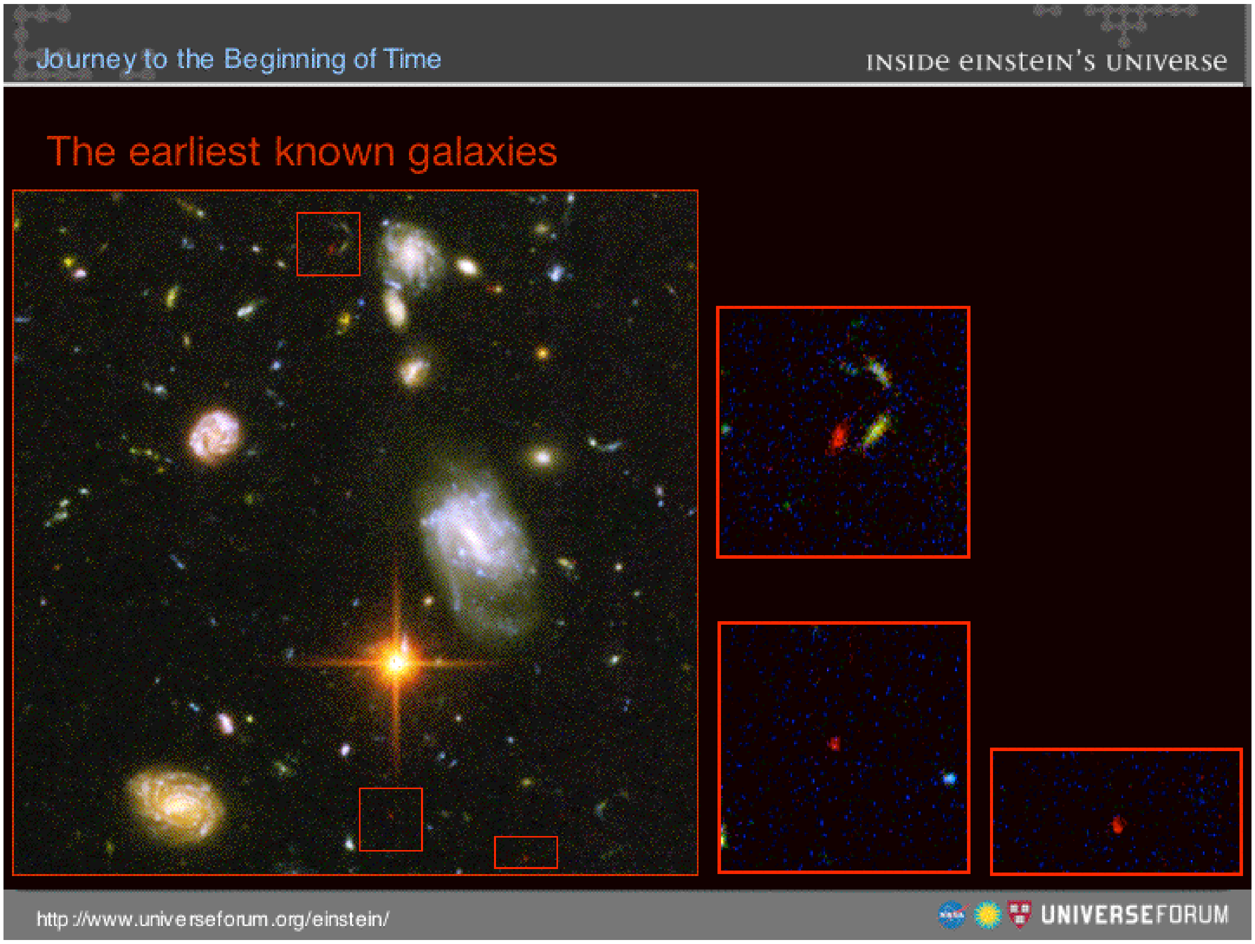
They are fully formed! (GALAXY) If we could travel instantly through space to get to distant spiral galaxies, they would probably look like our own Milky Way looks today.

Step 15 – A Big Round of Applause for our Time Travelers
It must be exhausting to travel for millions of years, so we should probably thank our volunteers and let them return to their seats.

Step 16 – Telescopes are Time Machines
Suggested Visual: The Hubble Ultra Deep Field, image or fly-through
Image: http://hubblesite.org/newscenter/newsdesk/archive/releases/2004/07/
Animation:
http://hubblesite.org/newscenter/newsdesk/archive/releases/2004/28/video/b
The image is pictured above. In order to run the animation, you will need to make sure it is saved in the same folder as this presentation.

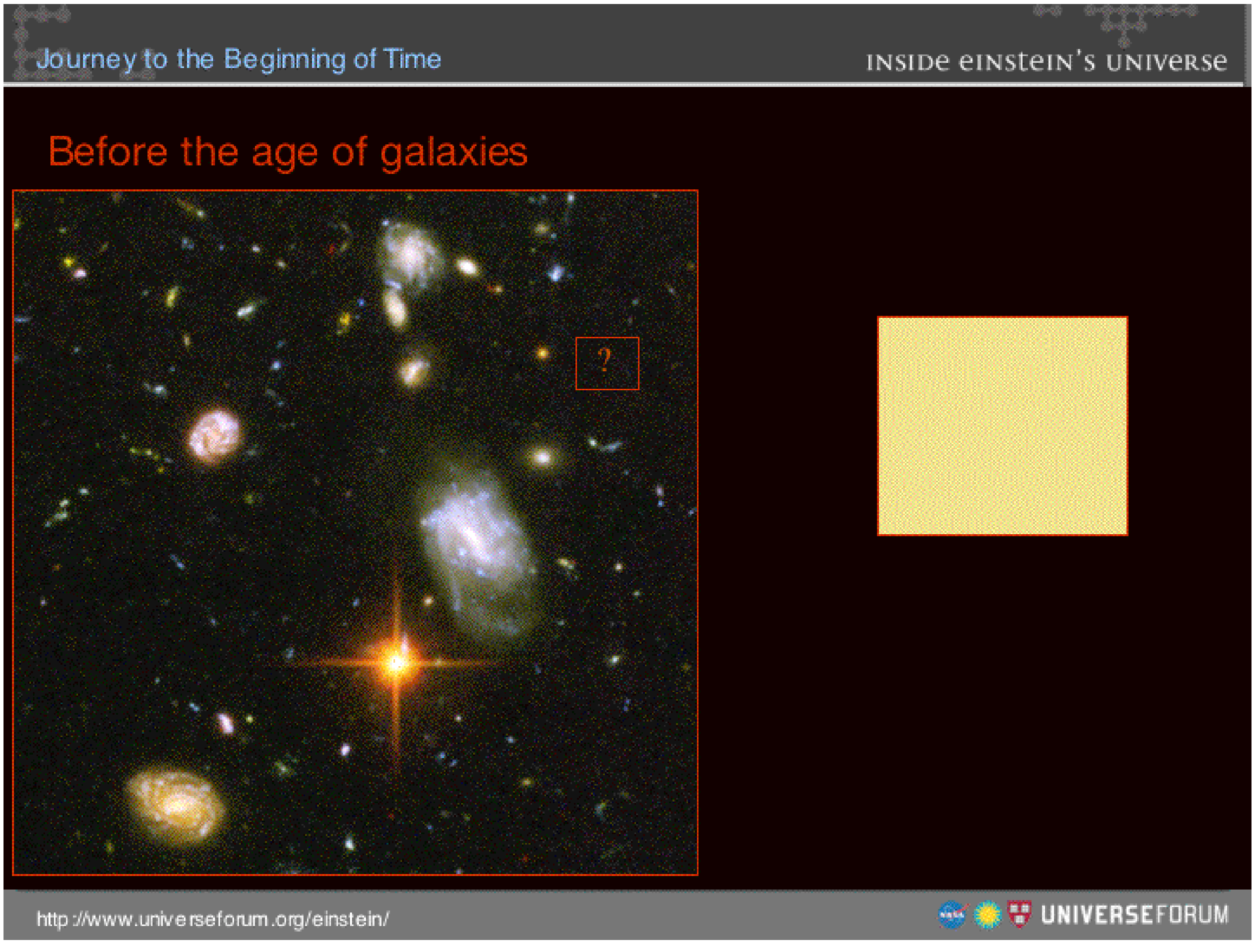
The further out in space we look, the more distant galaxies we see. Our volunteers have just shown us, however, that the more distant the galaxy, the longer ago light left it to travel to our telescope. Therefore, as we look out in space, we are also looking back in time.

The Hubble Ultra Deep Field is a very important image. With a few exceptions, every fuzzy point of light in this image is a galaxy. The larger-looking ones are the closest and the smallest-looking ones are the most distant. Light from these farthest galaxies has been traveling for 12 billion years. We see these galaxies as they looked 12 billion years ago, when stars were first beginning to shine.



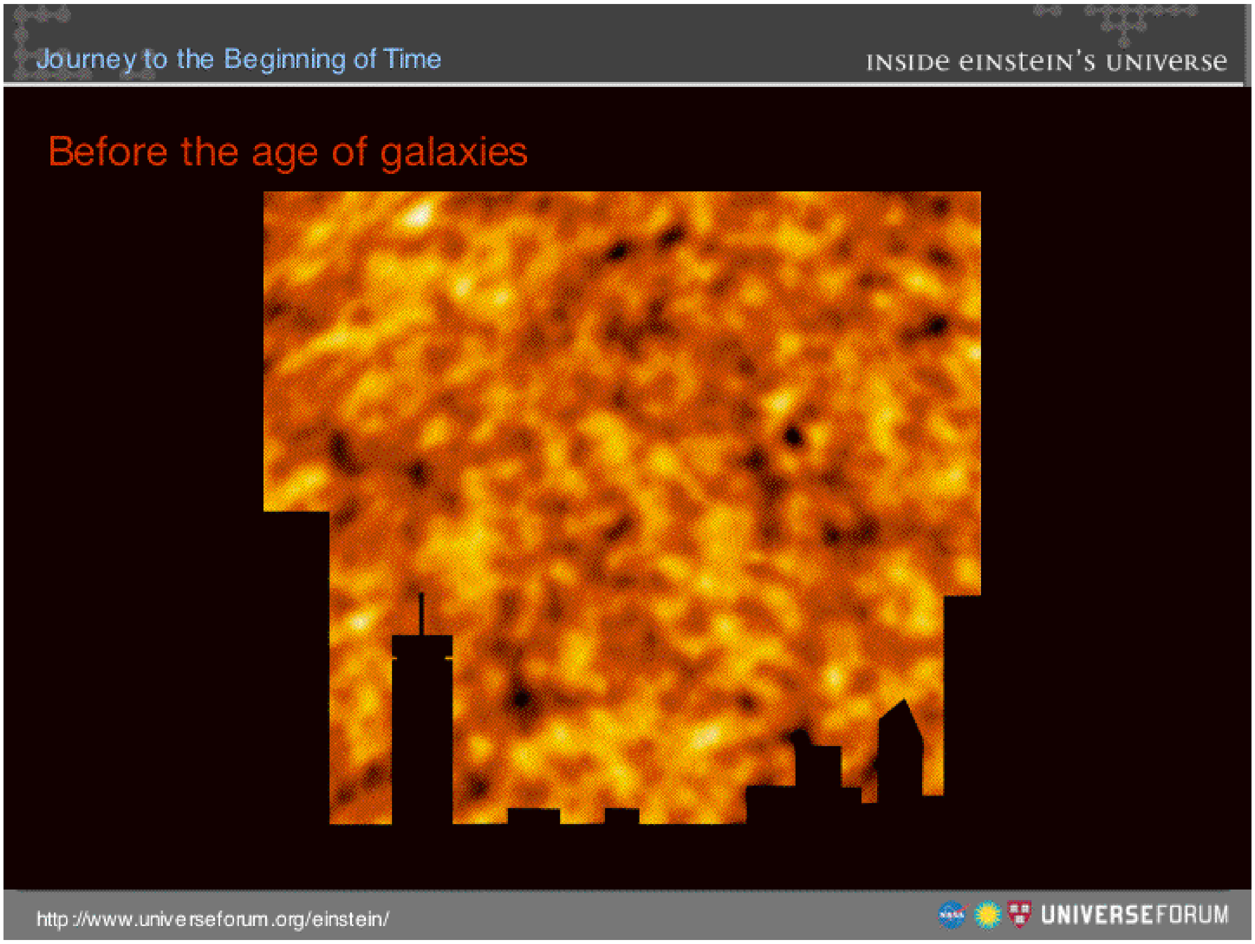
Step 17 – The Earliest Galaxies
Suggested Visual: ancient red galaxies in the Hubble Ultra Deep Field
Above image taken from:
http://hubblesite.org/newscenter/newsdesk/archive/releases/2004/28/image/a

Zooming in on a small section of the Hubble Ultra Deep Field, we see tiny red blobs. (You may have to increase the contrast in order for your audience to see them.) At the time this script was produced, these galaxies were the earliest galaxies astronomers have been able to observe. They look they way we think all galaxies look very early in their lives.



Step 17.5 – Transition to "Before the Age of Galaxies"
Suggested Visual: focus on a dark patch of sky, and a "zoom" of that box as a bright uniform field
http://hubblesite.org/newscenter/newsdesk/archive/releases/2004/28/image/a

What is beyond those primordial galaxies? Many billions of years ago the universe was too hot to form galaxies. This slide serves as a transition between ancient galaxies and the cosmic microwave background (next slide). The yellow box represents what the sky looks like in microwave light—a dense sea of hot gas.

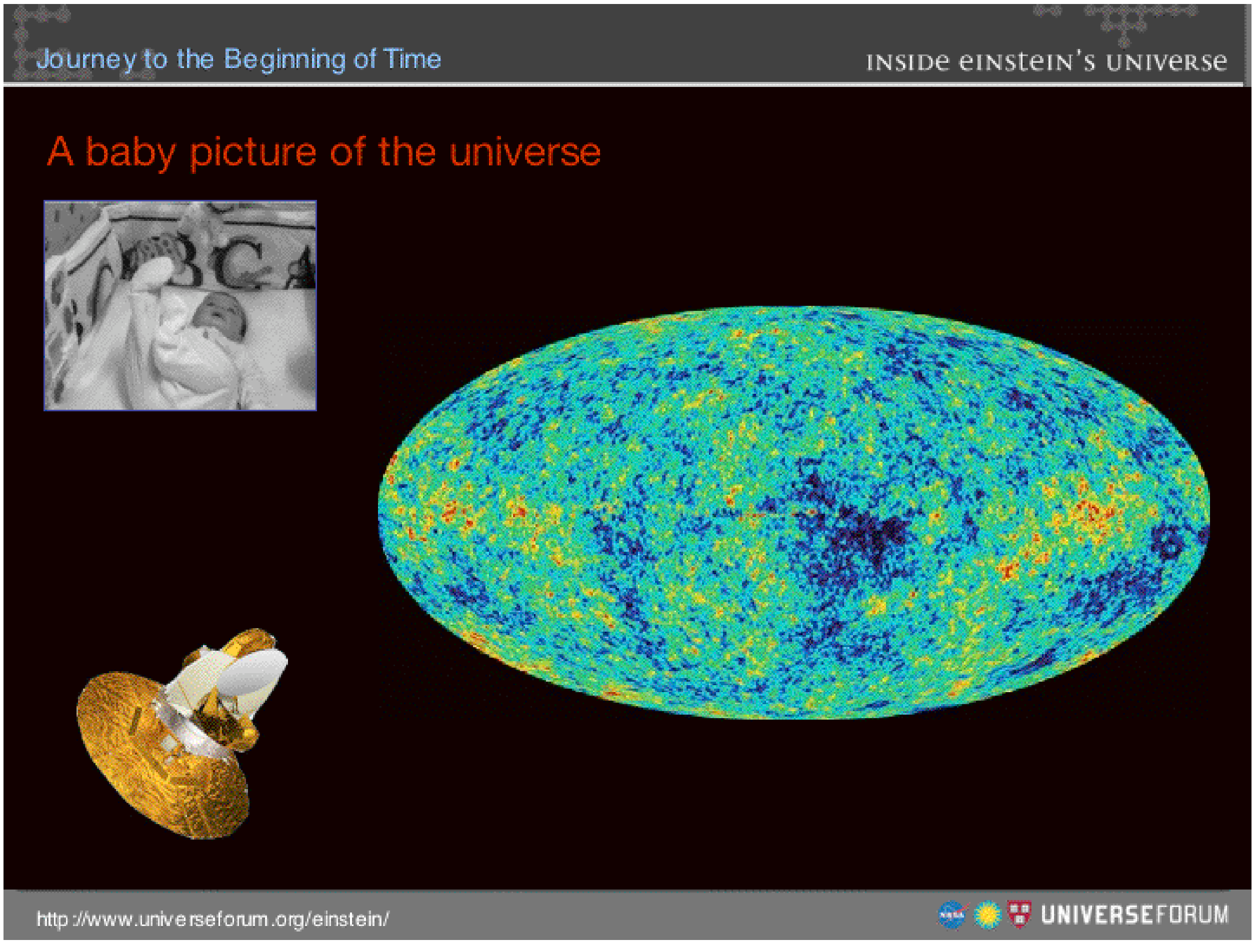


Step 18 – Before the Age of Galaxies
Suggested Visual: The Cosmic Microwave Background, against a skyline
What is really amazing is that we can use our telescopes to see back to a time when there were no galaxies! Before stars or galaxies existed, the whole universe was a sea of hot gas. Living in this early universe would have been like living inside the Sun – a hot, dense plasma soup.

Using special detectors we can detect this sea of gas, all around us. In fact, when we look at the night sky with these detectors we see light that has been traveling for almost 14 billion years to reach us. Everywhere we look we see this light. It is left over heat from the Big Bang!

(Click mouse to “increase contrast”)

The glow is very uniform until we turn up the contrast…on very small scales the temperature of this leftover heat varies. The differences between the dark and light areas of the second image are just a few thousandths of a degree.

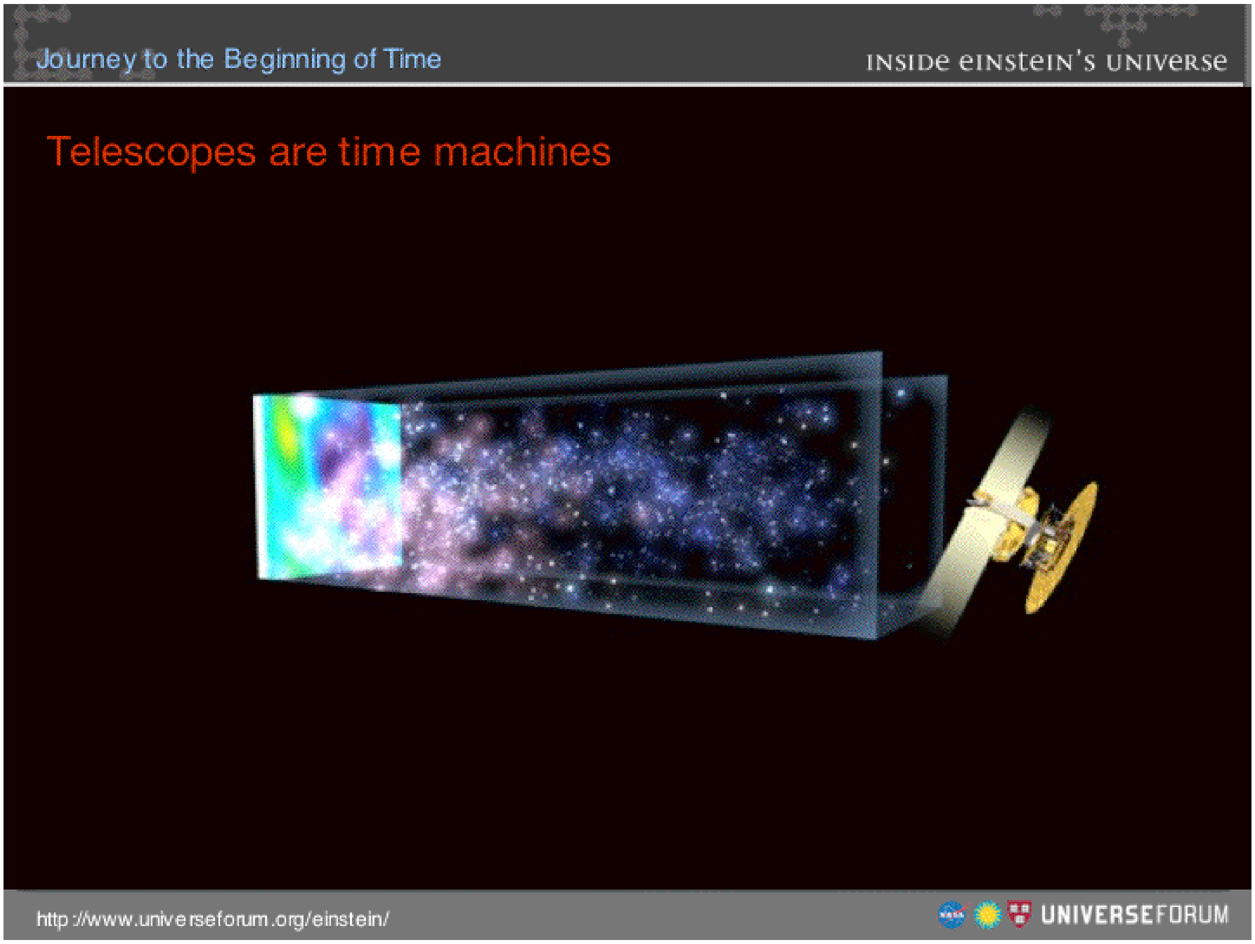


Step 19 – The Baby Picture of the Universe
Suggested Visual: WMAP image of the Cosmic Microwave Background + baby + WMAP space craft
The WMAP image can be downloaded here: http://wmap.gsfc.nasa.gov/m_or.html

This light has been detected and carefully mapped across the entire sky by the Wilkinson Microwave Anisotropy Probe. Looking at this map is like looking at the baby picture of the universe. This is not a picture of the universe as it appears now, but rather, how it appeared when it was very young. You may wish to use a baby picture of your grandparent to illustrate this idea…a young picture of a very mature object.

If this movie does not appear on the screen, please download the sixth animation down on this page: http://wmap.gsfc.nasa.gov/m_or/mr_media2.html caption: "See how the structure of the Universe evolved from WMAP's "baby picture" of the Big Bang through the clumping and ignition of matter (which caused reionization) up to the present."

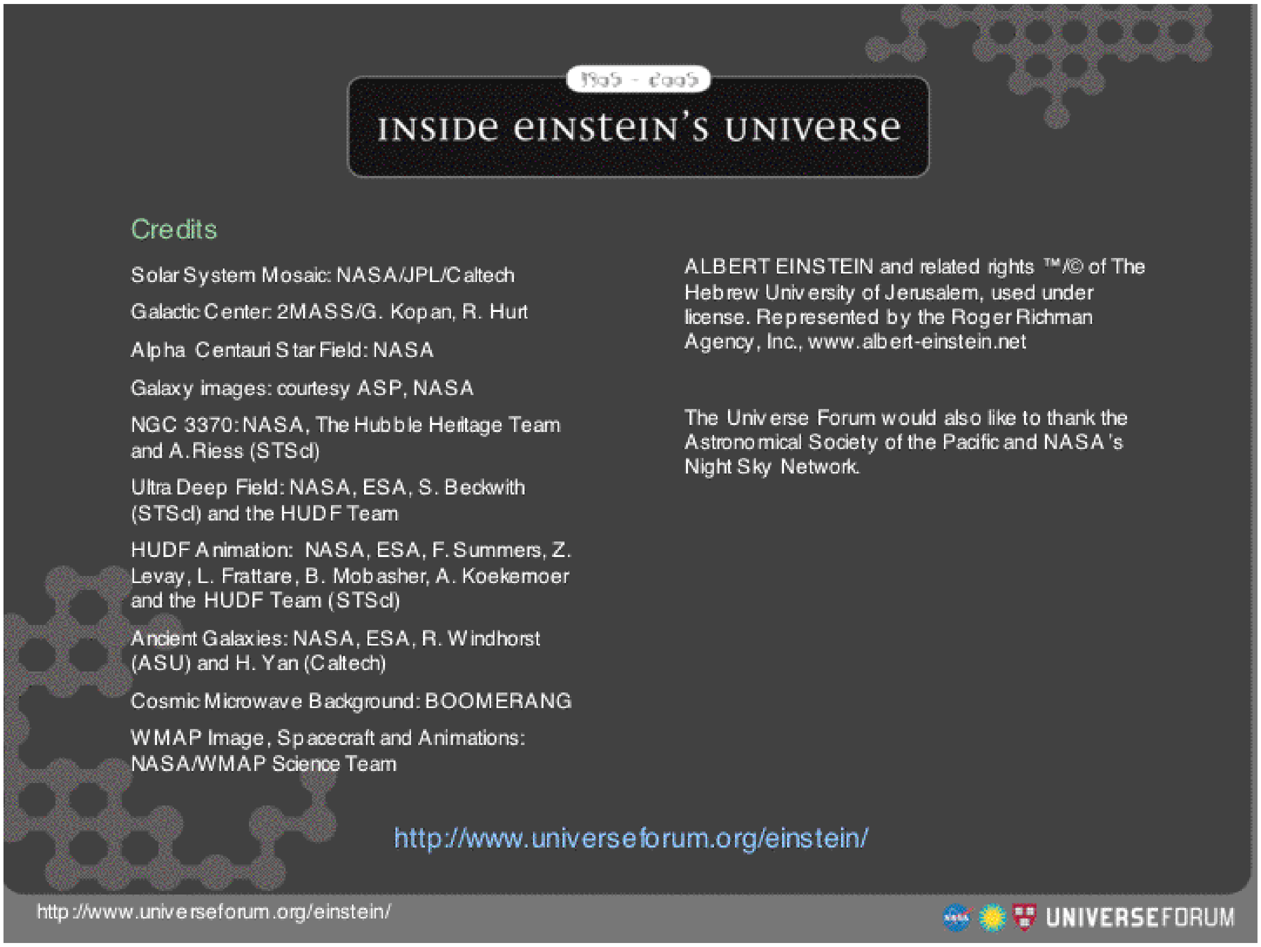
This animation shows a map of the cosmic microwave background (a sea of microwave frequency light that covers the entire sky) - the the oldest light in the universe, as seen today by WMAP .Temperature fluctuations (seen as differences in color) arose from the slight clumping of material in the infant Universe, which ultimately led to the vast structures of galaxies we see today. Matter condenses as gravity pulls matter from regions of lower density onto regions of higher density, matter condenses, forming gas. 200 million years after the Big Bang, the era of the first stars begins. Gas has condensed and heated up to temperatures high enough to initiate nuclear fusion, the engine of the stars. As more stars turn on, galaxy chains form along those filaments creating a web of structure. Finally, the universe enters the modern era, billions upon billions of stars and galaxies... all from the seeds planted in the infant Universe. The final shot shows the WMAP telescope as it looks back through space and time…every slice o the "box" moving right to left represents an earlier era in the history of the universe. The limit of our view is the cosmic microwave background.



Looking out in space is looking back in time:

The x-axis on this diagram represents time. On the far right, today, we see the WMAP space craft, the telescope that recorded the very detailed picture shown in the last two slides. As we move further to the left, the slices of space represented by the y- and z-axes, show different stages in the universe's history. The darker blue areas (toward the right) show well-evolved galaxies and stars, while the fuzzier, brighter areas represent the time when the universe was less evolved. The limit of our view is the WMAP baby picture - a sea of microwave light. To learn more about WMAP and the cosmic microwave background, please visit http://wmap.gsfc.nasa.gov/

We are limited in our view of the universe by the time it takes light to reach us, not a physical edge to space. The whole universe may be much larger than the universe we observe.



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