How big and how old is the universe?

The challenge

It's a big universe out there—but *how* big? And where did it come from in the first place? The Armchair Philosopher's League has been debating these questions and getting nowhere. Now they've asked you to help. Your challenge is in three parts:

Scouting the Universe. Use the telescope to create a gallery of galaxies far beyond our own Milky Way Galaxy.

Telescope as Time Machine. Using your gallery of images, estimate the distance to each galaxy. Report on: How long does it take light from these galaxies to get to Earth? What was happening on Earth when the light that you imaged left each of these galaxies?

Evidence for the Big Bang. Look for a pattern to the *motions* of the galaxies you imaged, and use your results to infer what the universe was like in the distant past.

Left: *The Sombrero Galaxy, as seen by the Hubble Space Telescope.* NASA / HST

Your ideas about the universe.

What do you think lies beyond our own Milky Way galaxy? Are there galaxies of stars beyond our own? Do you think creatures live there?

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Do you think space goes on forever? If so, could it be filled with galaxies like our own?

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Do you think the universe always existed? If not, what came before?

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What are your questions about the universe?

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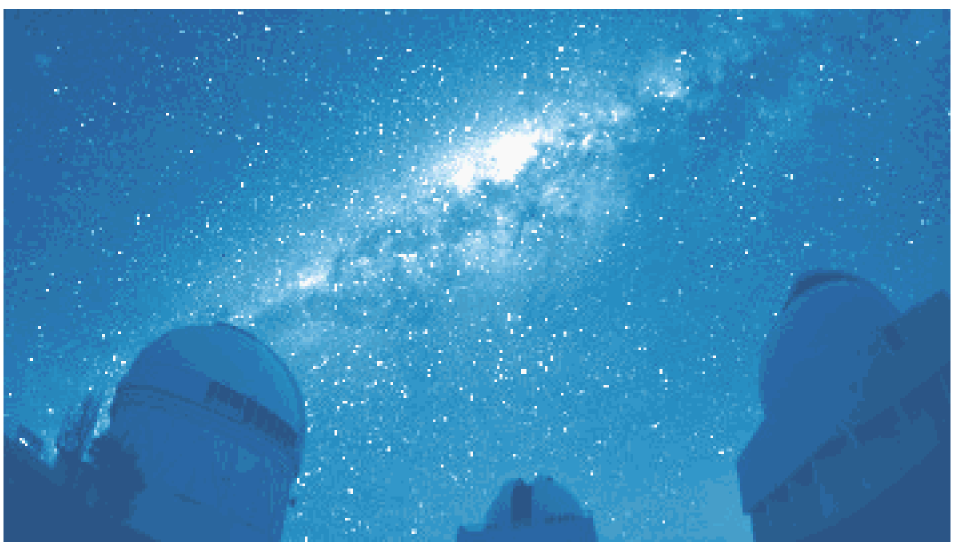
Briefing Room: "What's My Cosmic Address?"

If a group of aliens somewhere in the universe wanted to mail you a letter, where would they send it? What's your cosmic address?

My Name:
My Town:
My State:
My Country:
My Planet:
My Star:
My Galaxy:

Our Sun is just one of more 100 billion stars that together form our galaxy, called the Milky Way galaxy. (The word "galaxy" comes from the Greek word for milk, because all those stars seem to form a band across the sky that looks like milk.)



The view from Earth, looking out at the stars in our Milky Way galaxy. The individual stars you see are the ones that are nearest to us. The milky band contains stars that are so far away, and so numerous, that they seem to blend together. Photo courtesy Roger Smith, Cerro Tololo Interamerican Observatory.

For every star you can see at night, there are 50 million more stars in the Milky Way galaxy that you can't see — because they're too far and too faint.

Our Milky Way galaxy is shaped like a giant pinwheel. The galaxy rotates slowly around its center, taking several hundred million years to turn once.

The artist's drawing below shows what our Milky Way galaxy would look like if you could see it from outside.   At the scale of this drawing, the individual stars in the Milky Way are much too small to see: In fact, our entire solar system — the Sun and all nine planets — would be smaller than an atom in this drawing! We are about two-thirds of the way out from the center to the edge of the galaxy.

"We are here."

At the scale of this drawing, the individual stars, including our Sun, are too small to see.

Artist's drawing of what the Milky Way galaxy would look like as seen from outside. Drawing courtesy National Geographic Society.

Despite the drawing's appearance, the galaxy is mostly empty space, because the distance between stars is so large. It would take light about 100,000 years to travel across the galaxy. We say the size of the galaxy is about 100,000 light-years across. Each light-year is about 6 trillion miles. (See Exploration 3.)

A universe of galaxies. Our Milky Way is just one galaxy of many billions of galaxies that fill the universe we can observe from Earth. The photograph below shows the galaxies in just a tiny patch of the night sky. (How tiny? Hold a single grain of rice at arm's length. That's the amount of sky shown!)

In the photo you can make out just one star, which is part of our own Milky Way galaxy. Each of the other dots of light in the photo is an entire galaxy, composed of billions of stars! It's a big universe out there!

The galaxies we can see in a tiny patch of sky. Photo credit: European Southern Observatory.

Can you find the star? There's just a single star in this image. Every other smudge of light is a distant galaxy, each containing billions of stars!

Heads UP! Observing galaxies with the unaided eye.

When you visit a location far from city lights, you can get a good view of what a galaxy looks like, as seen from the INSIDE: Just observe the great band of light that marks our Milky Way galaxy.

You'll see it best in the summer, when at night the Earth faces towards the our galaxy's bright center. This band of light is made up of billions of stars — as well as clouds of dust and gas — that are too far and too faint to see individually.

From the Northern Hemisphere, you can only see one other galaxy beyond our own with your unaided eye: The Andromeda galaxy is visible in summer and fall as a faint, fuzzy patch in the constellation Andromeda. (You'll see it best out of the corner of your eye.) It is the furthest object in the universe that you can see with your naked eye—about 2 million light-years away!

Part 1: What do galaxies look like?

Creating a Gallery of Galaxy Images

Your first challenge is to use the telescope to image several galaxies beyond our own Milky Way galaxy. In this activity, we'll concentrate on finding **spiral galaxies** similar to our own Milky Way galaxy.

First your team will choose the galaxies you want to explore. After you have taken an image of the galaxies and downloaded them, you will need to use an image-processing program to bring out the galaxies' fine details. Finally, you'll print the images to create your "gallery of galaxies" and to use in the next part of the challenge.

1. **Choose the galaxies** that your team will image: Your team will be responsible for imaging four galaxies: one from each of the four sets of galaxies listed on the "Scope it Out" page. If a galaxy you have selected is *not* in the night sky tonight (i.e., wrong season for viewing), then you may use an image of the galaxy from the Image Archive instead.

IMPORTANT: Check with the other teams to make sure that, together, the teams have imaged as many *different* galaxies as possible. But it does not matter if more than one team images the same galaxy.

2. **Log on to the telescope** and use the suggested settings on the "Scope it Out" page to take your images.

   Discuss with your team: Does it matter whether all your images are taken with the same exposure time? How would different exposure times affect your images?

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3. **Download your images** from the telescope Web site as soon after they are taken as you can. Download your images in the FITS image format, following the instructions on the Web page.

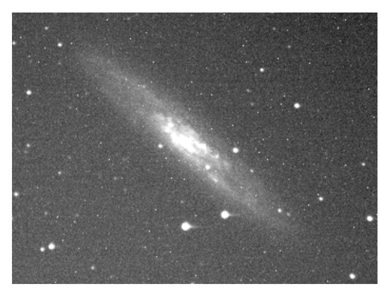
   Download: When you find the image on your computer, download it in the FITS format. (To do this, click and hold on the "Save as FITS file" option just above your image.) Choose "Save as SOURCE" rather than as TEXT.

4. **Name each image file** with the name of the galaxy, so that you can easily tell which galaxy is which. If needed, rename the image file to include the name of the galaxy.

5. **Process your images** using the image-processing software on your computer. Open the image. Under the **Process** menu, select **Adjust Image** and process until you are satisfied with the result. Try to bring out the faint outer part of the galaxy as best as you can; otherwise, the galaxy will look smaller, and therefore further away, than it really is.

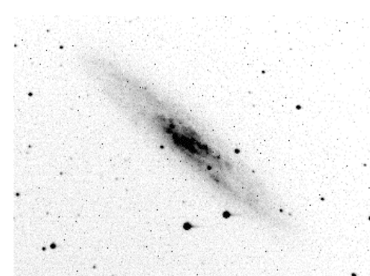
6. **Measure the size of each galaxy**. When you are satisfied that your image shows the whole galaxy, measure the width of the galaxy as follows: Position the cursor at one end of the galaxy. Click and hold, while dragging the cursor across the longest part of the galaxy. The width of the galaxy, in pixels, appears in the information box at the top of the image.

7. **Record the galaxy size on the DATA PAGE.** You'll need this measurement to determine the distance to the galaxy in Part 2 of the challenge.



8. **Save your processed image** as a GIF file. Make sure it is labeled with the name of the galaxy.

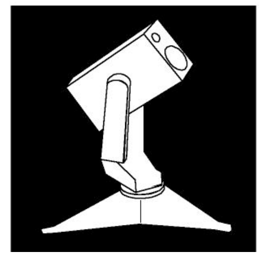
   Important: Be sure to download your image promptly. Save it in both formats. Name the file and keep it. Process the image and print the image.



9. **Print your images** at normal size (100%). **TIP:** Instead of printing a white galaxy on a black background, you can INVERT your image in your image-processing program.

This produces a grey or black galaxy on a white background. It looks interesting, is easier to see, and saves your printer's ink! (Under the **Process** menu, select **Invert**. Then save the inverted image as a GIF file.)

'Scope it out: Taking images of galaxies



Choose your galaxies: On the next page are the sky addresses for some interesting galaxies to explore. Choose one galaxy from each Galaxy Set on the list. (You can also image galaxies that are not on the list, if you like.) Then use the recommended settings below to control the telescope.

Note: If a galaxy you have chosen is not up in the sky tonight (refer to viewing chart), then you may download the galaxy image from the Image Archive.

Camera: Use the main camera, zoomed out

Filters: You won't need to use a filter for this investigation.

Exposure time: Galaxies are very faint. Try using a 45- or 60-second exposure.

"Why do the galaxies have funny names?"

The letter "M" in the galaxy names refers to Charles Messier, an 18th-century French astronomer. In 1787 Messier created a catalog of fuzzy objects in the sky that were not stars and were not comets. The "NGC" in the galaxy names refers to the New General Catalog (NGC) of Nebulae and Star Clusters. Compiled in 1888 in Ireland by John Dreyer, the catalog listed 13,000 objects in the sky.

Suggested galaxies to observe

✔	GALAXY	SKY COORDINATES			
		Right Ascension (R.A.)		Declination (Dec.)	
		Hours	Minutes	Degrees	Minutes
	Galaxy Set 1				
	NGC 253	00 h	47.7 m	-25 o	16 '
	M 31	01	42.7	41	16
	M 33	01	33.8	30	39
	NGC 891	02	22.6	42	21
	M 81	09	55.6	69	4
	M 101	14	3.2	54	21
	NGC 5907	15	15.9	56	19
	Galaxy Set 2				
	NGC 2903	09	32.2	21	30
	M 96	10	46.8	11	49
	M 65	11	18.8	13	5.7
	M 109	11	57.7	53	22
	M 104	12	40	-11	37
	M 106	12	18	47	25.3
	M 51	13	29.9	47	12
	Galaxy Set 3				
	NGC 4013	11	58.5	43	57
	NGC 4636	12	42.9	02	41
	M 58	12	37.7	11	49
	NGC 5005	13	10.9	37	3
	Galaxy Set 4				
	NGC 2300	07	32.3	85	42.5
	NGC 2543	08	13	36	15
	NGC 3614	11	18.3	45	45
	NGC 4119	12	8.1	10	22.7
	NGC 4565	12	36.3	25	59

Middle of this Month	***RA highest at midnight***
Jan	*07h*
Feb	*09*
Mar	*11*
Apr	*13*
May	*15*
Jun	*17*
Jul	*19*
Aug	*21*
Sep	*23*
Oct	*01*
Nov	*03*
Dec	*05*

Find the current month in the table. The number at right shows the Right Ascension that will be highest at midnight.

A Right Ascension that is several hours less (or more) than this will be highest that many hours earlier (or later) in the evening.

Example: In March, a galaxy with RA of 11 will be highest around midnight. A galaxy with RA of 7 will be highest 4 hours before midnight, at 8 PM.

Reflecting on your images.

Why do you think you can't make out the individual stars in the galaxies you imaged?

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How does the width of the widest galaxy in your images compare to the width of the full Moon image? If galaxies are so wide, then why don't you see them when you look at the night sky?

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How do the shapes of your galaxies compare with the spiral shape of our Milky Way galaxy?

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At least one planet in our galaxy is teeming with life: ours. Do you think that the galaxies you explored could contain life? Intelligent life? What do you think are the chances that there is someone—or something—in one of your galaxies looking back at the Milky Way galaxy with a telescope... asking the same questions?

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Part 2: How large is the universe?

Determining the distance to your galaxies

Your next challenge is to estimate the distances to the galaxies that you imaged. The point of this activity is not just to get a number, but to explore what your results mean. Your results will help you get a better handle on the big question, "How large is the universe?"

Planning your investigation

Discuss with your team: How will you determine the distance to the galaxy in your image? What do you need to know?

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Carrying out the investigation

1. For this investigation, *assume* that all the spiral galaxies that you imaged are about the same size as our Milky Way galaxy, which is about 100,000 light-years across. (One light-year is about 6 trillion miles.)

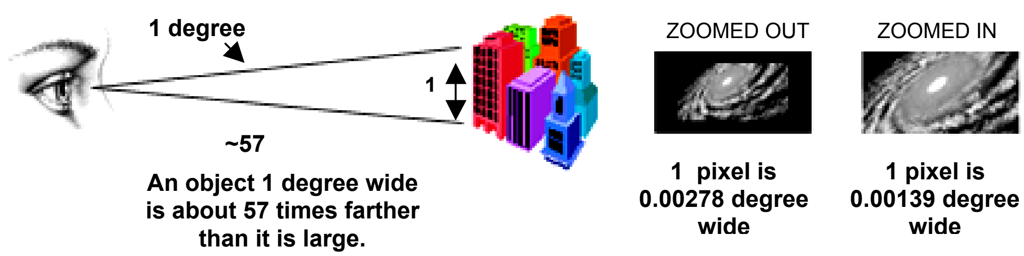
ASSUMPTION: ***The spiral galaxies in your images are about the same size as the Milky Way galaxy, 100,000 light-years across.***

2. Once you know how large an object is, then you can determine how far away it is by measuring its *angular size*:

An object that appears one degree wide is about 57 times farther away than it is large. (See diagram below.) So if one of your galaxies appears one degree wide, then it must be 57 times 100,000 light-years away, or about 5,700,000 light-years away.

If the object is farther away, its angular size will appear *proportionally smaller*. (For example, when it is three times as far, it appears one-third the size.) Note: This is true only for the small angles you'll be working with in your images.

In each zoomed-out image, one pixel spans 0.00278 degrees. So, for example, a galaxy that is 100 pixels wide in your image would be 0.278 degrees across. (Each zoomed-out image is 550 pixels across, which spans a little less than one degree.)



3. Using the information above, determine the angular width of each of your galaxies. (This is just the **number of pixels** across the width of your galaxy, times the **angular width of each pixel**, which is 0.00278 degrees per pixel.) Enter the angular width of each galaxy on your DATA PAGE.

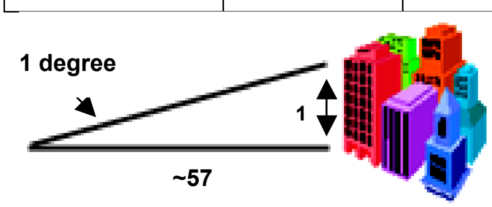
4. Calculate the distance to each of your galaxies. Use the "rule of 57" and remember that "smaller means proportionally further."

Enter the distance you have determined for each galaxy on your DATA PAGE.

DISTANCE TO GALAXIES: DATA PAGE

The distance to various spiral galaxies if they are assumed to be about 100,000 light-years wide.

GALAXY (name)	**WIDTH** (in pixels)	**WIDTH** (degrees)	**DISTANCE** (light-years)	**SPEED** (kilometers/sec) use **+** for away from us use **-** for towards us



ZOOMED OUT

1 pixel is 0.00278 degree wide

ZOOMED IN

1 pixel is 0.00139 degree wide

Reflecting on your results

Infinite universe?

What's the furthest distance that you could hope to see a galaxy with the MicroObservatory telescopes? (Assume that the smallest galaxy you can RELIABLY see in a zoomed-out image is 2 pixels wide.)

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Based on your results, what, if anything, can you conclude about the size of the universe as a whole?

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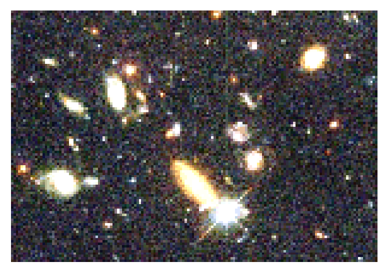
The most distant galaxies seen to date were imaged by the Hubble Space Telescope. The farthest galaxy in the image is about 12 billion light-years from Earth. The exposure time for this image was ten days. Compare that with the 60 seconds for the image you took!



Is the universe infinitely large? Are there galaxies out to infinity? Astronomers think there could be, but no one knows for sure. You'll find out why this question is so difficult to answer, as you continue with the challenge.

Frozen in time?

Suppose one of your galaxies were moving at almost the speed of light across the telescope's field of view. Could you ever hope to see its motion by taking several images of the galaxy days apart—or even months or years apart? About how long would it take for a galaxy to move even 1 pixel across the field of view in your image?

(You'll need to know how many miles each pixel represents, at the distance of your galaxy.)

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Telescope as time machine?

When you drink from a stream, the water you drink was once at the source of the stream. It took **time** for the water to flow from the source to you. In the same way, the light that you captured with the telescope took **time** to travel from the galaxies to you.

About how long does it take light from each of your galaxies to reach Earth?

Light takes one year to travel a distance of one light-year.

One light-year is about 6 trillion miles.

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Do your galaxy images show the galaxies as they look NOW or as they looked in the past? Why?

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Pick one of your galaxies. What was happening on Earth when the light that made this galaxy's image first set out on its long journey to Earth?

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The telescope is a true time machine: the farther out in space we look, the farther back in time we see. Could we see as far back as the beginning of the universe? In the next part of the challenge, you'll gather evidence about what the universe was like when it was still a "baby"!

Part 3: How old is the universe?

Has the universe always existed, or did it have a beginning? If the universe had a beginning, when did it start and how did it come into existence? In the absence of direct evidence, many cultures throughout history have woven different stories about the universe and its creation. Only in the last century have humans had the right tools to explore this ancient cosmic question.

One line of evidence is to examine the *motions* of the galaxies. By looking at how the galaxies are moving at present, we might be able to figure out what they were doing in the past. If we can figure out where the galaxies were in the past, that might tell us something about the origin of the universe.

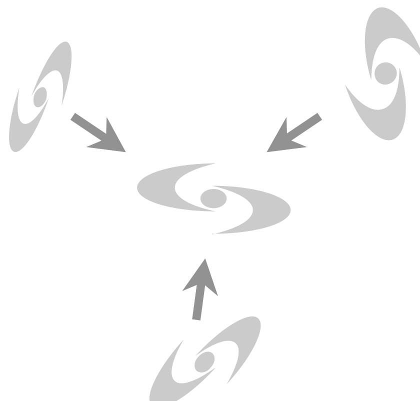
Your challenge is to combine your results about the distance to your galaxies, with published data about how fast the galaxies are moving, in order to see if you can discover a *pattern* to the motion of the galaxies you imaged. Then you'll try to use the pattern you observe to figure out how old the universe is!

Team discussion.

Here are three competing possibilities for how your galaxies might be moving. With your team, discuss all three possibilities. Then make your own prediction.

Possibility 1. "Gravity rules!" All the galaxies could be moving towards us.

"Gravity attracts, so I think that everything should be falling together. I think all those galaxies out there are moving towards each other, and towards our own Milky Way galaxy. Sooner or later, the galaxies will come crashing together!"



"I say gravity rules! I think that all the galaxies will be falling towards us."

If this theory is correct, what would the universe have looked like a long time in the past?

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If this theory is correct, what might the universe look like a long time in the future?

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Possibility 2: "Balance rules!" Galaxies might not move at all.

"We say 'balance rules'! We think the galaxies are not moving at all."

"We think the universe must be in perfect balance. If the galaxies were falling towards each other, wouldn't the universe have collapsed long ago?

Somehow, the universe must be in balance. We think the galaxies are not moving at all."

If this theory is correct, what would the universe have looked like a long time ago?

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If this theory is correct, what will the universe look like a long time in the future?

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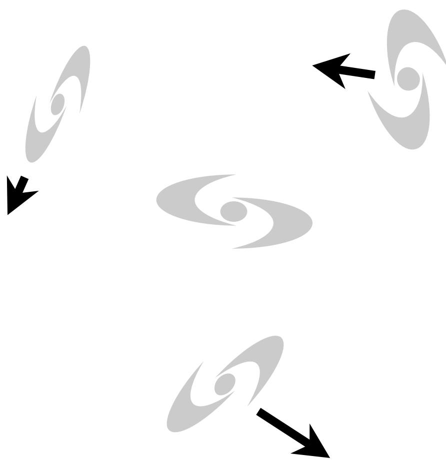
Possibility 3: "Swarm of bees!" The galaxies might move randomly.

" I think that all the galaxies will be moving randomly — about half moving towards us and about half moving away."

"I think the galaxies are too far apart for gravity to make a difference. Maybe the galaxies are all moving randomly, like a swarm of bees on a hot day. Some galaxies are moving towards us, and some are moving away."



If this theory is correct, what would the universe have looked like a long time ago?

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If this theory is correct, what would the universe look like a long time in the future?

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Your prediction.

What pattern do you think you will find when you examine the motions of the galaxies? Choose one:

_____ I think galaxies will all be moving towards us. Gravity rules!

_____ I think galaxies will be moving randomly. Near, far… doesn't matter!

_____ I think galaxies will all be stationary. Universe in balance!

_____ Other. Here's the pattern of motion that I expect, and why:

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Gathering the evidence: "Is there a pattern to the motion of my galaxies?"

So far, you have found out how *far* from Earth each of your galaxies is. Now you're going to find out how *fast* each of your galaxies is moving (towards or away from Earth). Then you're going to graph the speed of each galaxy versus its distance from Earth, and see if you can find a pattern in your data. The final part of the challenge is to interpret your results.

Find the speed of your galaxies.

In part 2, you found that galaxies are so far away that there is no hope of directly seeing them move by using a telescope. In fact, no astronomer has ever seen a galaxy move, even over a lifetime; the galaxies are just too far away.

But astronomers *can* tell whether a galaxy is moving towards or away from us, and how fast it is moving. The principle is the same as the one used to clock a tennis serve, baseball pitch, or speeding car. (See Box, next page.) You can learn more about this method by visiting:

http://cfa-www.harvard.edu/webscope/galSpeeds

To find out how fast each of your galaxies is moving, you'll use data that astronomers have already published and posted on the World Wide Web.

1. On the World Wide Web, find the published results for how fast each of your galaxies is moving. Go to NASA's Extra-Galactic Database (NED). Use this Web address:

   http://nedwww.ipac.caltech.edu/forms/z.html

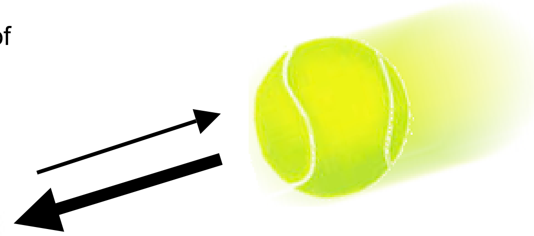
2. On the Website, enter the name or number of your galaxy. (Do NOT use hyphens or dashes. E.g., M33 or M 33 or NGC 2300 are okay.)

3. Hit the button marked "redshifts."

Clocking Venus Williams' Serve

Venus Williams hit a world-record tennis serve when she was 18 years old. It was clocked at 125 miles per hour.

"Radar gun" emits light of *known* energy...

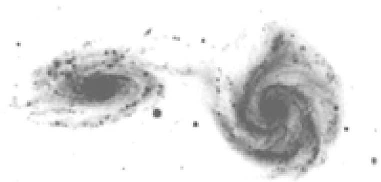


...Light bounces off tennis ball, gains energy due to speed of ball.

Radar gun measures increased energy of incoming light.

Clocking a Galaxy's Speed

We can't use a radar gun on a galaxy, so we use light of *known* energy emitted by the galaxy itself...



Stars in galaxy emit light of *known* energy...

...When received on Earth, the light will have *more* energy if galaxy moving towards us... *less* energy if galaxy is moving away.

4. Use the first line of data. The column marked "km/s" lists the speed of your galaxy in kilometers per second. A minus sign (-) means the galaxy is moving towards us. A plus sign (+) or no sign means the galaxy is moving away from us.

5. For each galaxy on your DATA PAGE, enter the speed of the galaxy and whether it is moving towards us (-) or away from us (+).

Graphing your data.

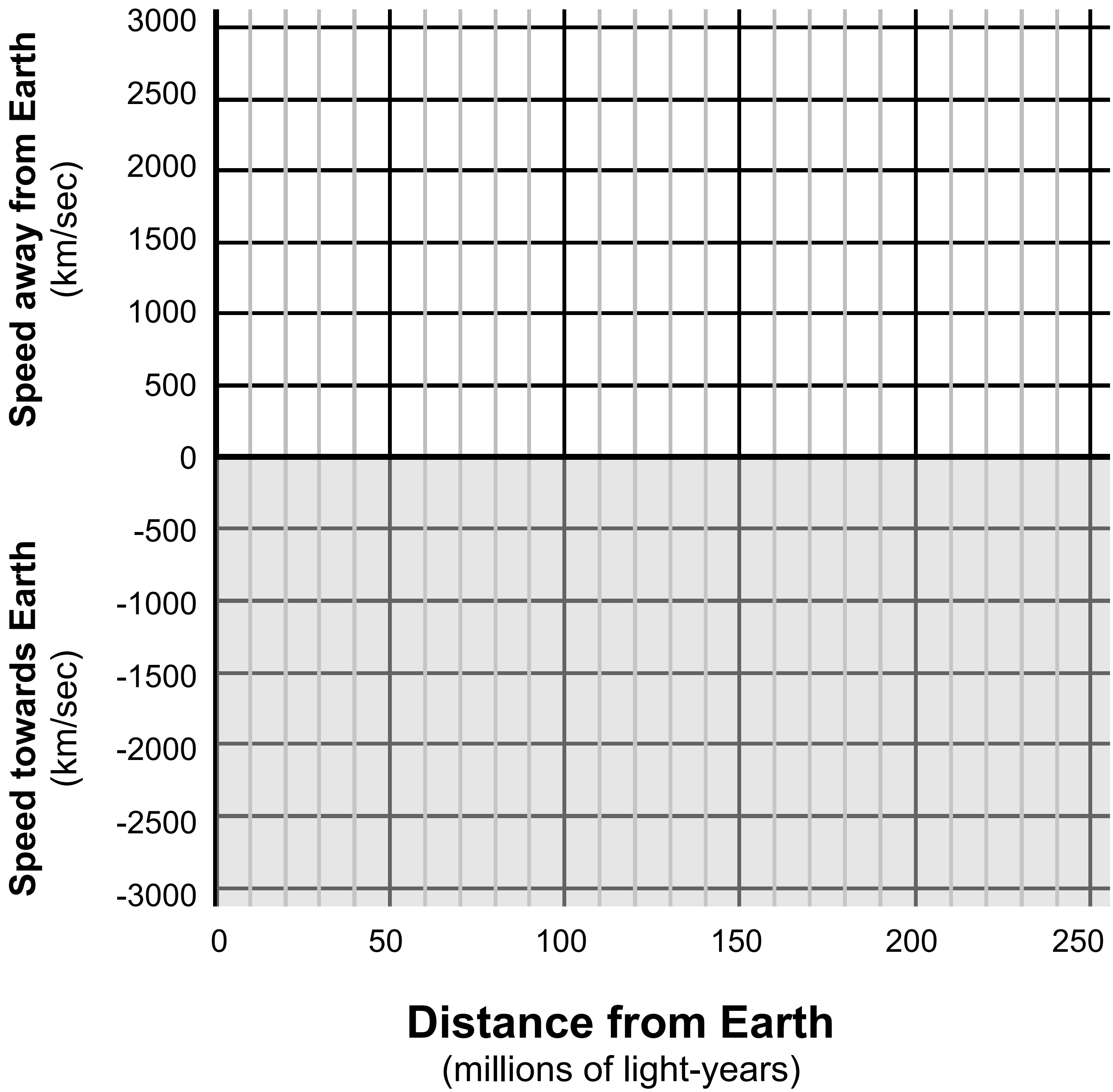
Now you're ready to see if there is any connection between **the distance to each galaxy** and **how fast it is moving**.

With the other teams in your class, make a graph of the distance to each galaxy vs. the galaxy's speed. Use either the overhead projector slide that your teacher will provide OR the graph paper on the next page.

Remember to plot galaxies moving towards us below the axis, and galaxies that are moving away from us above the axis.

How old is the universe?

Plot galaxy's speed vs. galaxy's distance from Earth



Reflecting on your results

Expanding universe?

Are most of the galaxies moving towards Earth, or away from Earth? Are you surprised?

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Is there a pattern to your data? In general, are galaxies that are further away from Earth moving differently from galaxies that are closer? In what way?

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Based on the pattern of motion for the galaxies that you've found, what would the universe have looked like long ago?

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Is this result what you expected to find? (Compare your result with the prediction you made earlier.)

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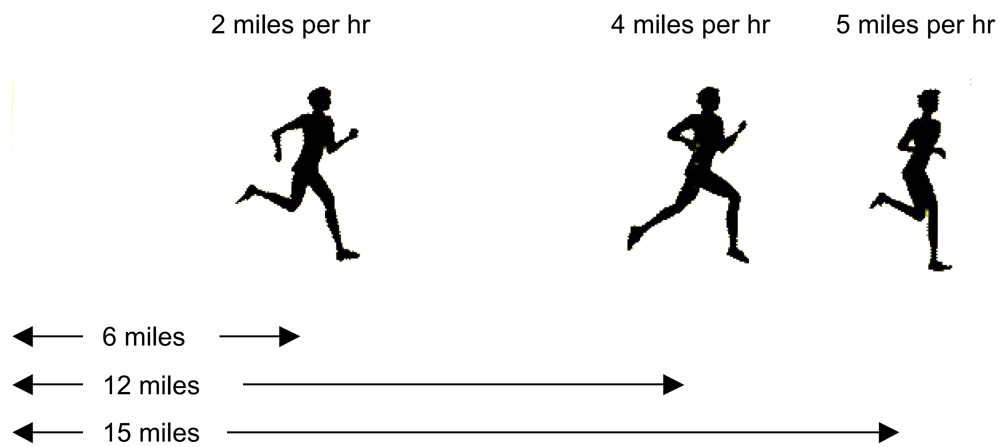
Why do you think that the *closest* galaxies might be moving towards us? Why might some of the galaxies *not* fit the pattern you've found?

Age of the universe

Imagine a road race in which all the runners run at different speeds. The fastest runners will be further from the starting line than the slower runners. The figure below shows the speeds and distances from the starting line for three runners in a race. See if you can tell from the measurements below: How long ago did the race start?



Suppose the runners have been getting slower as the race goes on. How would that affect your estimate for how long ago the race began?

Try using your graph to run the "galaxy race" backwards in time. In the past, where were the galaxies in relation to each other?

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Based on the data in your graph, how long ago would the galaxies (or the material they're made of) all have been on top of each other? (Assume that each galaxy has always been moving at the same speed.)

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Based on your findings, estimate: How long has the universe has been expanding?

The universe has been expanding for about______________ years.

If the motion of the galaxies has been gradually slowing down with time, would the universe be older or younger than your estimate? Why?

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Observable universe: How big is it?

Now you can revisit the question, How far could we ever hope to see with our telescopes? Suppose there are galaxies, say, 200 billion light-years from Earth. Could you see those galaxies, if you had a powerful enough telescope? In thinking about this question, ask yourself, “Has there been enough time since the beginning of the universe for light to travel from those very distant galaxies to the telescope? If not, what would you see when you looked through the all-powerful telescope?

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Briefing Room:
What Was the Big Bang?

Congratulations! You have discovered evidence for one of the most spectacular and unexpected events in our universe: the Big Bang. During the last century, scientists have pieced together a truly amazing story:

> About 14 billion years ago, our universe began expanding from an incredibly hot, dense state called the Big Bang. During the Big Bang, all the matter and energy that we observe today was packed into a region no bigger than a grapefruit! Over billions of years, the universe expanded and cooled. Under the tug of gravity, matter clumped to form stars and galaxies of stars, and all the other objects in the universe.

In 1908, **Henriett Leavitt** found a new way to determine the distance to galaxies.

Many lines of evidence confirm the Big Bang scenario. Here are two of the major pieces of evidence:

Clue #1: Galaxies in the universe are rushing away from each other. Their motion shows that about 14 billion years ago, all of the matter in our universe was together in one spot.

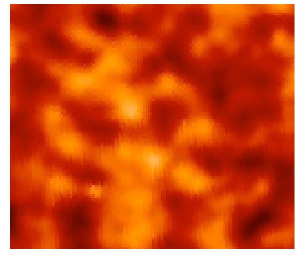
The evidence you and your team gathered has been confirmed by many scientists over the last century, who have observed hundreds of thousands of galaxies out to great distances and have found the same result as you.

1929. Using Leavitt's method, **Edwin Hubble** discovers that galaxies are speeding away from Earth—the further the faster. *Image credit: California Institute of Technology*

By running the "movie" of this expanding universe backwards in time, we conclude that galaxies were much closer together in the past. About 14 billion years ago, all the matter in the universe would have been together in one spot.

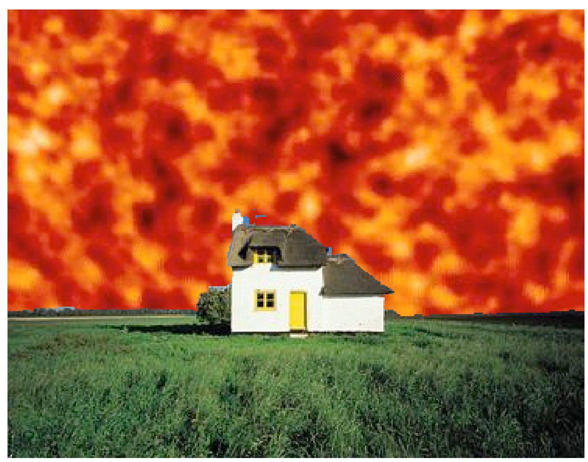
Clue #2: We can see the light left over from the Big Bang.

You might think that light from the Big Bang would be long gone. But the Big Bang took place *everywhere* in space at the same time, so light from the Big Bang fills the universe. Some of this light is just now arriving at Earth, having traveled for 14 billion years from very distant regions of the universe. This light is no longer visible to the naked eye: As the universe expanded and cooled, this light lost energy and dimmed. The energy (and wavelength) of this light is now in the microwave region, similar to the light in your microwave oven. It is detectable only by special instruments.



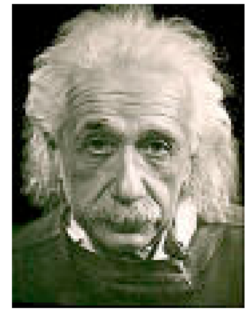
The furthest we can see: Light left over from shortly after the Big Bang. *Image courtesy NASA BOOMERANG mission.*

This light left over from the Big Bang was first discovered in 1964 by Arno Penzias and Robert Wilson, who won the Nobel Prize for their discovery. In 2001, NASA's BOOMERANG mission captured the image of Big Bang light shown at right. This is our oldest and furthest view of the universe. It shows the infant universe about 300,000 years after the Big Bang. The fuzzy spots are clumps of matter that will eventually form galaxies and clusters of galaxies.



If you could see light from the Big Bang with your eye, you would see that it fills the entire night sky. The figure at right shows how the night sky would look if you *could* see this light (colorized and contrast enhanced). **Left**: image by Lee Frost. **Right:** Composite with image from NASA's BOOMERANG mission.

Clue #3: Einstein's theory of gravity predicted the Big Bang.



Albert Einstein's 1917 theory of gravity led to the prediction that the universe has been expanding since the Big Bang.

Since "gravity attracts," you can imagine what a surprise it was for Albert Einstein that his new theory of gravity predicted that the universe might be expanding—that the galaxies might be rushing away from each other. Whereas Isaac Newton described gravity as a force between two objects, Einstein described gravity as a distortion of the space and time around an object. Einstein's new theory made a strange prediction: a universe filled with matter might actually be expanding. Einstein didn't believe the prediction—until Edwin Hubble discovered in 1929 that the universe really is expanding.

A common misconception is that the Big Bang was an explosion that flung matter outwards in all directions from a central point. In the modern view, the universe is expanding because *more space is coming into existence* between the galaxies. As result, the distance between galaxies grows larger—much as the distance between raisins get larger as you bake a raisin loaf and watch the dough expand. Wrap you mind around that idea!

We understand what happened just after the Big Bang, but not what came before.

We know only that universe expanded from an extremely hot and dense state—the Big Bang. But we don't yet know what happened before the Big Bang. Where did the matter and energy in the universe come from? How did space and time come into existence in the first place? What lies beyond what we can see? Why is there something instead of nothing?

No one knows... yet. But nature has a way of leaving us good clues. And human imagination and ingenuity has a way of finding and interpreting those clues. Perhaps you and your friends will be among the detectives who will solve these great mysteries of the universe.