K-12 EDUCATOR'S GUIDE

Table Contents

This K–12 Educator's Guide includes activities and information to help extend the learning experience after students watch *Secrets of the Universe*. The film explores cutting-edge science experiments taking place around the world, including at the Large Hadron Collider at CERN (looking at the smallest particles in the universe) and the Laser Interferometer Gravitational-Wave Observatory (LIGO) (where gravitational wave detectors are hearing the collisions of massive black holes billions of light years away). This Educator's Guide includes a timeline of the universe from the Big Bang to today and hands-on activities that share the process of science with your students.

Learning Goals for K-12 Students:

- Science is a creative and collaborative endeavor of thinking deeply, asking questions, finding patterns and building models.
- An understanding of nature at the smallest scales is needed to understand how the universe behaves at the largest scales.
- Technology extends human senses, allowing us to observe the universe at different scales.

Key Terms

Big Bang: a scientific model that says that the universe began 13.8 billion years ago as an incredibly small, densely packed region of space

Black hole: a region of space where the gravity is so intense that matter and light cannot escape. In most cases, a black hole forms when a massive star (25 Suns or higher) ends its life.

Exoplanet: a planet that orbits a star other than our Sun

Gravitational wave: a distortion or ripple in spacetime, produced by colliding stars or black holes, that travels at the speed of light

James Webb Space Telescope: a space telescope that will be 1.5 million kilometers from Earth

Large Hadron Collider: the world's largest particle accelerator

Laser Interferometer Gravitational-Wave Observatory (LIGO): a gravitational wave observatory with two detectors in Washington State and Louisiana

Light curve: a graph that displays the change in brightness of a star over time. A temporary dip in brightness may be caused by an exoplanet crossing in front of its star.

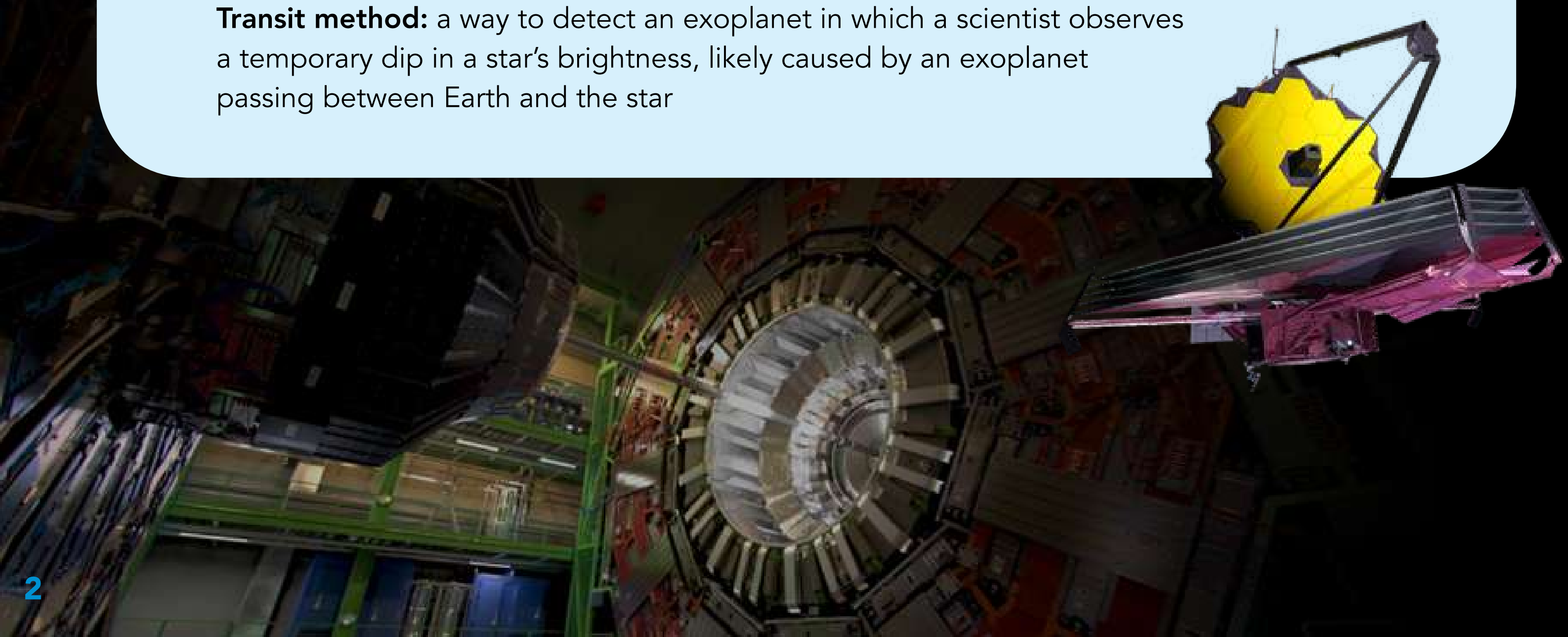
Light year: the distance light travels in a year; approximately 9.4 trillion kilometers

Particle accelerator: a device that makes charged particles move very quickly at high speeds

Quark-gluon plasma: a "soup" of freely moving quarks and gluons. Usually quarks and gluons are bound inside protons and neutrons. They can move freely only when temperatures and densities are extremely high.

Redshift: the increase in the wavelength of light caused by the expansion of the universe. The resulting light is redder or redshifted.

Transit method: a way to detect an exoplanet in which a scientist observes a temporary dip in a star's brightness, likely caused by an exoplanet passing between Earth and the star



What Is Science?

Science is about asking questions, thinking deeply and testing our ideas with observations and experiments. Science is a process involving many people working together to understand our universe from the smallest particle to the entire cosmos. From the eradication of certain diseases to solar cells and smartphones, science has changed our world.

Secrets of the Universe

The IMAX film *Secrets of the Universe* explores cutting-edge scientific theories and experiments. It …. Include more when we see rough cut …..

Learn more about the theories and experiments by visiting WEBSITE.

Models

The process often starts with a simple question about the natural world, like "Why is it dark at night?" or "Why do penguins have wings?" Scientists make careful observations and develop models to explain what they see.

Experiments

We can never know for sure that a model is right, but we can know if it is wrong. Scientists design experiments to check their models. Models that fail a test are wrong and must be replaced or modified. The Large Hadron Collider at CERN does experiments to test our best model for what makes up all the matter in the universe.

Applications

Once a model has been tested many times, it can be applied by engineers, designers and technicians to make new transformative technologies. Einstein's model of gravity, general relativity, was essential in developing the GPS satellites that help us navigate to our destinations every day.

Science is never complete. Each new discovery leads to more questions.

Scientists

Scientists study the universe at all scales. Here are two scientists: one looks at the smallest scale of matter while the other looks at distant objects in the sky.

Manuel Calderón de la Barca Sánchez is a physics professor at UC Davis. Manuel studies the conditions of the early universe right after the Big Bang. The early universe was extremely hot: hotter than the Sun. It was so hot that protons and neutrons could not exist. Instead, the universe was filled with **quark-gluon plasma**. To study this strange state of matter, Manuel uses the largest machine on the planet, the Large Hadron Collider, to create incredibly hot, tiny pockets of quark-gluon plasma. This plasma is very difficult to study because it is hard to make and lasts for less than a second.

Maya Burhanpurkar is pursuing a bachelor's degree in physics and computer science at Harvard. Maya has always been passionate about science. When she was 10, Maya built a lab in her basement to study antibiotics. She continued doing experiments throughout high school and competed in several major science fairs. During a gap year between high school and college, she worked at Perimeter Institute writing computer programs to help detect radio bursts from space using the CHIME telescope. Maya says she is drawn to scientific research "because of the opportunity to answer unanswered questions" and "… make fundamental discoveries about the universe around us."

Grades K-4

NGSS Disciplinary Core Idea

- PS4 Waves and Their Applications in Technologies for Information Transfer

NGSS Science and Engineering Practice

- Asking Questions and Defining Problems

Try This! What's That Sound?

In this activity, students make sounds by vibrating different materials, and then learn that **gravitational waves** are another type of vibration.

Materials

- wooden mallet or stick
- several different objects (e.g. metal pot, wooden table, carpet, tiled floor, glass of water, drum)

What to Do

Strike the objects with the wooden mallet. What do they sound like? Which ones are loudest? Which ones are quietest?

Go Further!

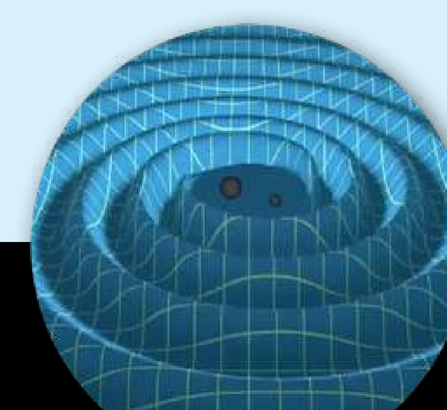
Gravitational waves are like any other vibration. If our ears were sensitive enough, we would be able to hear gravitational waves as they passed. Listen to an amplified gravitational wave in this clip: **www.ligo.caltech.edu/video/ligo20160211v2**

Laser Interferometer Gravitational-Wave Observatory

The **Laser Interferometer Gravitational-Wave Observatory (LIGO)** is one of the most precise instruments ever built. It detects ripples in space created by massive colliding objects like black holes. Scientists call these ripples gravitational waves. Gravitational waves stretch and squeeze space as they pass, leading to tiny changes in length. Even the most energetic collisions lead to changes in length on Earth less than the size of a proton!

Fun Fact

LIGO measures tiny changes caused by gravitational waves passing through Earth. These changes are unbelievably small: just one-hundred-millionth of the diameter of a hydrogen atom!



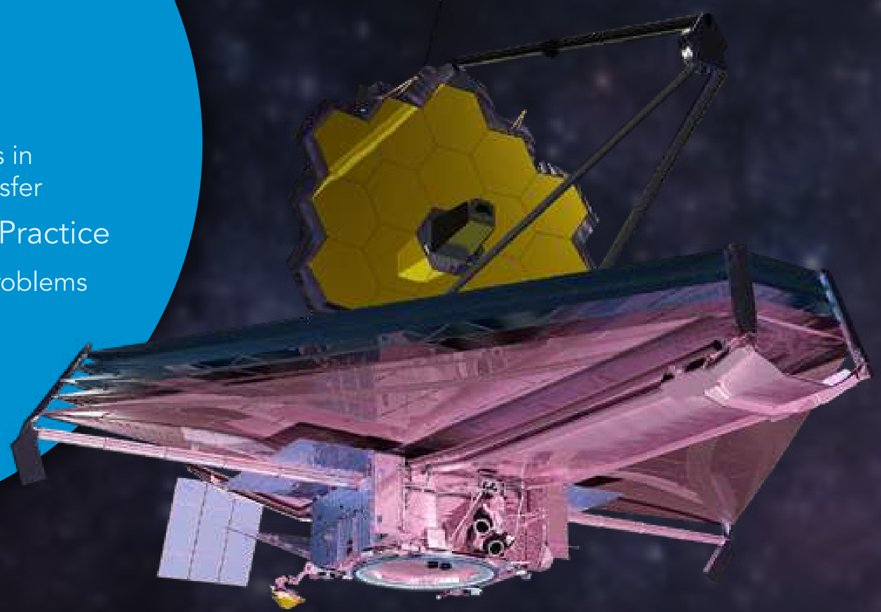
Grades K-4

NGSS Disciplinary Core Idea

- PS4 Waves and Their Applications in Technologies for Information Transfer

NGSS Science and Engineering Practice

- Asking Questions and Defining Problems



Try This! Why Put a Telescope in Space?

This simple demonstration illustrates why we need to put telescopes in space. Students use a spray bottle to mist a window, mimicking the blurring effects of the atmosphere.

Materials

- spray bottle filled with water

What to Do

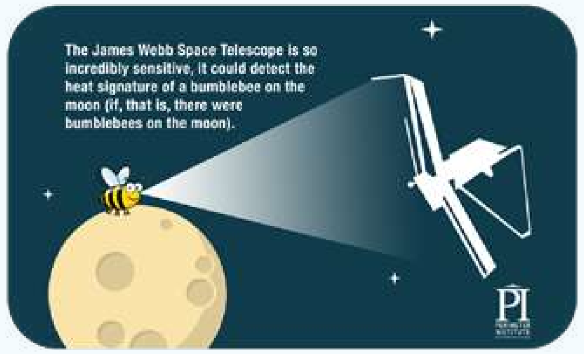
Take a look through a window. What do you see? Now take a water-filled spray bottle and cast a mist over the window. What do you see now? How does the water affect your view?

What's Happening?

Telescopes on Earth look through Earth's atmosphere to see distant stars, planets and galaxies. Earth's atmosphere blurs the picture just like the water sprayed on the window. To get a sharper, clearer picture we need to put telescopes where there is no atmosphere: in space.

James Webb Space Telescope

The James Webb Space Telescope (JWST) will be the biggest telescope ever put in space. With a mirror 6.5 m across, it will be 100 times more powerful than the Hubble Space Telescope. Unlike a typical mirror, the JWST looks like a honeycomb and is plated with gold. It will be sensitive enough to see a bumblebee on the Moon. That's pretty sweet!



Fun Fact

The amount of gold on the James Webb Space Telescope mirror, if melted down, would be the size of a golf ball.

Grades 5-8

NGSS Disciplinary Core Idea

- PS1 Matter and Its Interactions
- PS4 Waves and Their Applications in Technologies for Information Transfer

NGSS Science and Engineering Practice

- Asking Questions and Defining Problems

Try This! Learning with Light

Humans have never traveled beyond the Moon, and yet we have learned a lot about distant stars and planets just by looking at light. In this activity, students practice being scientists by observing different liquids and sorting them in different ways (e.g., color, viscosity, opacity). Have students rank the liquids based on how much light is transmitted. Discuss how the gases in exoplanet atmospheres can be detected.

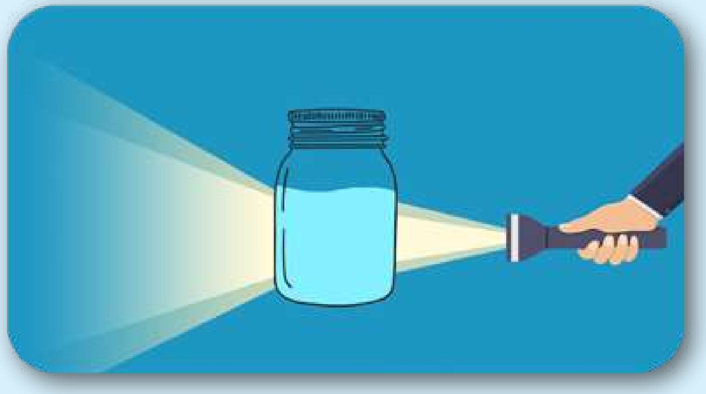
Materials

- different liquids in clear jars (e.g., liquid honey, milk, cream, vegetable oil, water, fruit juice)
- small flashlight

What to Do

Examine the different materials. How might you sort them? What inferences can you make?

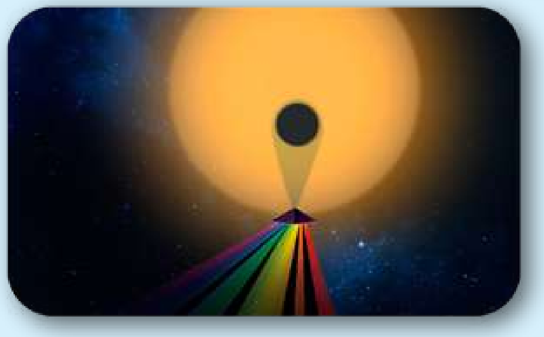
Try shining a flashlight through the jars. Which ones allow light to pass? Which block light? What does that tell you about the liquid?



What's Happening?

Light may be transmitted, reflected or absorbed by a material depending on its ingredients.

Liquids containing many solid particles transmit less light than those that contain few or no solid particles.



Exoplanet Atmosphere

We have found close to 4000 exoplanets orbiting stars in our galaxy. The James Webb Space Telescope will allow scientists to study the atmospheres of some of these planets. The JWST will collect starlight that grazes the planets, passing through their atmospheres. Elements in the atmosphere block some of the light. We can discover what is in the atmosphere by examining which colors of light are blocked.

Grades 5-8

NGSS Disciplinary Core Idea

- PS1 Matter and Its Interactions

NGSS Science and Engineering Practice

- Asking Questions and Defining Problems

Try This! Sparking Curiosity

In this activity, students reflect on the IMAX film Secrets of the Universe and generate questions for deeper learning.

Materials

- chart paper
- markers

What to Do

In small groups, discuss the IMAX film Secrets of the Universe. What do you still wonder about? Write your questions on chart paper and hang the paper on the wall. Do a gallery walk and examine the questions produced by other groups. Which questions are similar to your own? Which are different?

Go Further!

Choose a subject area and find like-minded peers who share the same interests. Select one or two questions and work together on an inquiry project.

Perimeter Institute

Scientists are always asking questions about the world around them as they look for better understanding. Driven by curiosity, physicists at Perimeter Institute try to understand the universe and the laws of nature from the smallest scales of subatomic particles to the largest scales of the cosmos.

Fun Fact

Blackboards are everywhere at Perimeter, where researchers use more than 6000 pieces of chalk each year.

Grades 5-8

NGSS Disciplinary Core Idea

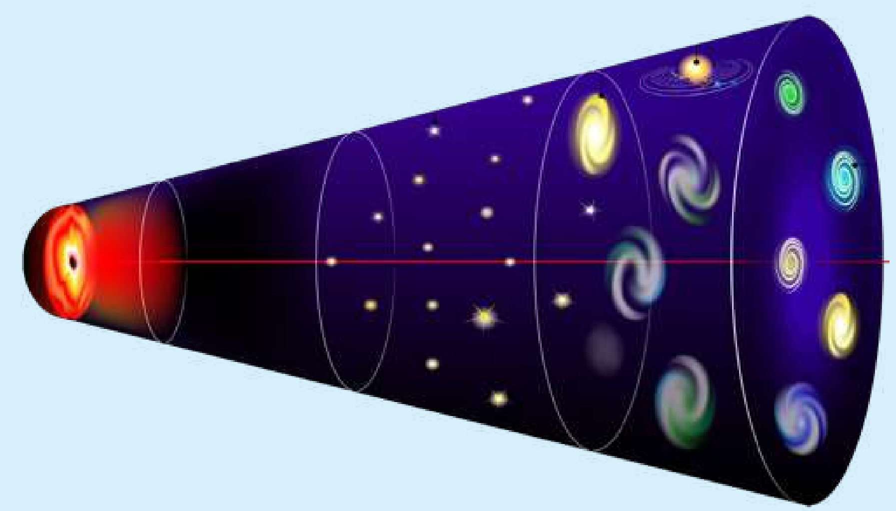
- PS3 Energy
- ESS1 Earth's Place in the Universe

NGSS Science and Engineering Practice

- Asking Questions and Defining Problems

Try This! Expansion and Cooling

Our universe is expanding. That means it must have been smaller in the past. How much smaller? In the **Big Bang**, 13.8 billion years ago, the universe began as a tremendous amount of energy packed into a space smaller than a grain of sand. This tiny space was extremely hot. As the universe expanded, it cooled. In this simple activity, students experience how the expansion of the universe leads to cooling.



What to Do

Experience how expansion leads to cooling just by blowing on your hand. First, try opening your mouth wide and puffing. How does it feel? Now try pursing your lips and blowing. Which one feels warmer? Which one feels cooler?

What's Happening?

When you purse your lips, the air is forced out in a narrow stream. The stream of air cools as it expands.

Grades 9-12

NGSS Disciplinary Core Idea

- PS4 Waves and Their Applications in Technologies for Information Transfer
- ESS1 Earth's Place in the Universe

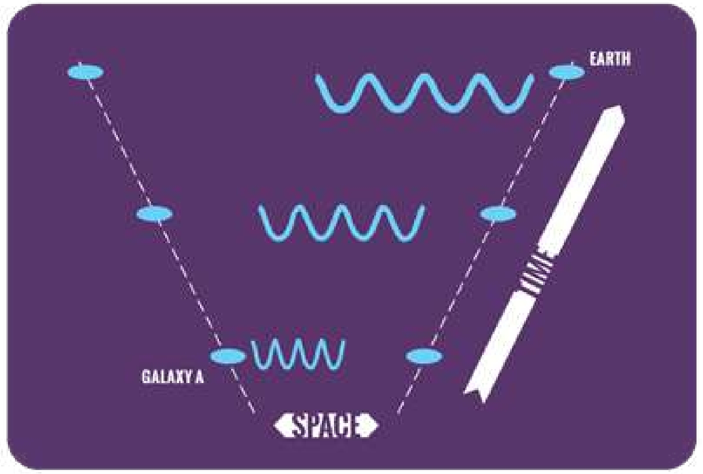
NGSS Science and Engineering Practice

- Asking Questions and Defining Problems

Try This! Discover Redshift

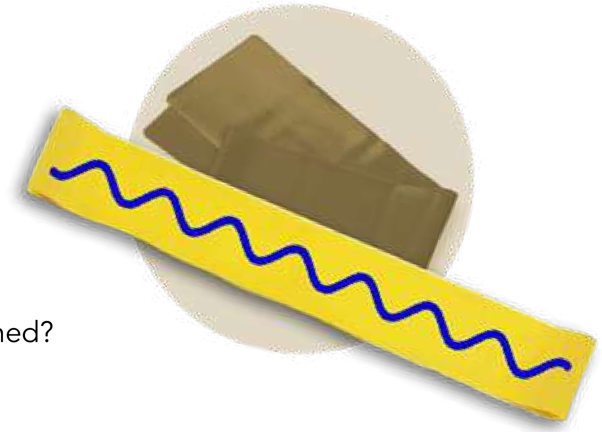
By looking at the light from distant galaxies, we have discovered that our universe is expanding. The space between galaxies is getting bigger and bigger. Light traveling through this expanding space gets redder due to the expansion.

In this activity, students model how the wavelength of light increases as it is stretched by the expanding universe.



Materials

- wide elastic band cut into a long strip
- markers



What to Do

Use a marker to draw a wave on the elastic band.

Hold both ends of the band and stretch it. What happens to the wavelength and amplitude of the wave when it is stretched?

What's Happening?

Light traveling through expanding space stretches along with the space. When light is stretched, its wavelength increases. Light with a longer wavelength is more red; light with a shorter wavelength is more blue. Stretching the wavelength makes the light redder. This is what astronomers call **redshift**. The farther away a galaxy is, the redder it looks.

Try This! Why Is the Large Hadron Collider So Big?

Grades 9-12

NGSS Disciplinary Core Idea

- PS2 Motion and Stability: Forces and Interactions
- PS3 Energy

NGSS Science and Engineering Practice

- Asking Questions and Defining Problems

This simple activity illustrates why the **Large Hadron Collider (LHC)** needs to have such a large circumference. Students make a marble move faster and faster and watch how the path of the marble is affected. This activity can be done as an experiment in groups or as a demonstration.

Large Hadron Collider

The Large Hadron Collider (LHC) is the biggest machine in the world and it studies the smallest objects in the universe! The LHC is a giant 27 km circular tunnel about 100 m underground. Scientists use magnets to steer tiny particles like protons into high-speed collisions. The collisions break the protons apart, which makes a spray of subatomic particles.

Materials

- marble
- large round bowl
- plastic wrap

What to Do

Put the marble in the bowl. Stretch plastic wrap over the top of the bowl to keep the marble inside. Wiggle the bowl back and forth so the marble starts to circle around. As you wiggle the bowl faster, the marble will also rotate faster. What happens to the path of the marble?

Fun Fact

The Large Hadron Collider counts as the world's largest fridge. The magnets in the tunnel are cooled to a frosty −271.3°C (1.9 K).

What's Happening?

The marble is like a proton going around the circular tunnel of the LHC. All moving objects tend to go in a straight line. The force needed to push them into a circular path depends on the speed of the object and the radius of the circle. In general, a faster object will move in a bigger circle. As you make the marble move faster, it needs a bigger circumference and climbs up the sides of the bowl.

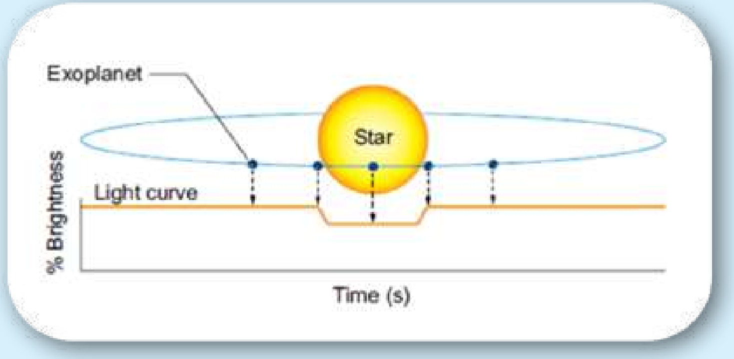
Grades 9-12

NGSS Disciplinary Core Idea

- PS4 Waves and Their Applications in Technologies for Information Transfer
- ESS1 Earth's Place in the Universe

Try This! Find an Exoplanet with Your Smartphone

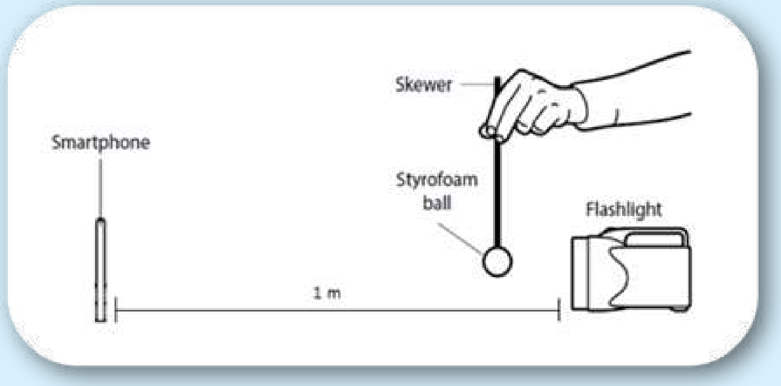
An **exoplanet** is a planet that orbits a star other than the Sun. Scientists have found close to 4000 exoplanets in our galaxy alone. This activity demonstrates one of the most common methods of detecting exoplanets: the **transit method**. Astronomers make precise measurements of the brightness of a star. When an orbiting exoplanet passes in front of the star (transits), it blocks some of the light. This causes a dip in the star's brightness. The graph of the brightness of the star plotted against time is called a **light curve**.



Materials

- 2 wooden skewers
- 2 Styrofoam balls, 1 large (~5 cm diameter) and 1 small (~2.5 cm diameter)
- large flashlight (> 10 cm in diameter)
- smartphone with front-facing camera
- light meter app with graphical display such as phyphox for Android and Google Science Journal for iOS

What to Do

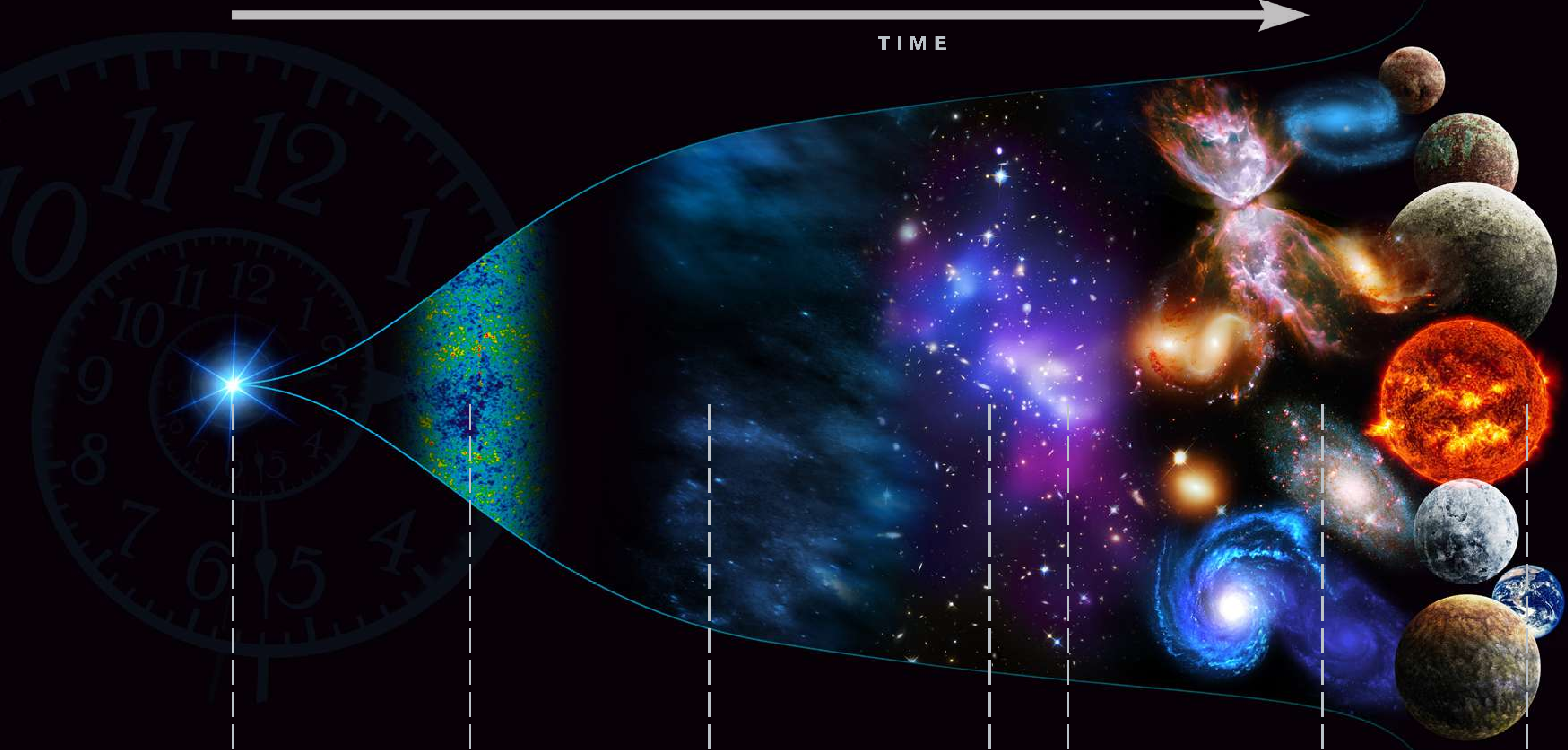


1. Form a group of three or four. Make sure at least one group member has a smartphone with the light meter app open and working.
2. Insert a wooden skewer into each Styrofoam ball. Set up the equipment as shown in the figure below.
3. Dim the lights and test the app by passing your hand between the phone and the flashlight. The light curve should dip.
4. Predict how the curve for a large planet will differ from the light curve for a smaller planet passing in front of the flashlight at the same speed and distance.
5. Conduct the experiment. Using the largest ball, move the ball across the face of the flashlight about 10 cm from the flashlight. Then repeat with the smaller ball. Make a sketch of both light curves.
6. Compare the light curves produced by the small and the large planet. Do they match your predictions?

Go Further!

What else can you learn about an exoplanet by examining the light curve? What challenges might you face detecting a real exoplanet–star system?

Timeline of the Universe



The Big Bang–the universe is filled with energy. Matter forms within minutes after the Big Bang.

Atoms form and light can travel through space, 380,000 years after the Big Bang.

First stars, 100 million years after the Big Bang.

First galaxies appear, 1 billion years after the Big Bang.

The Milky Way forms, 2.8 billion years after the Big Bang.

Solar system and Earth form, 9 billion years after the Big Bang.

Today, 13.8 billion years after the Big Bang.

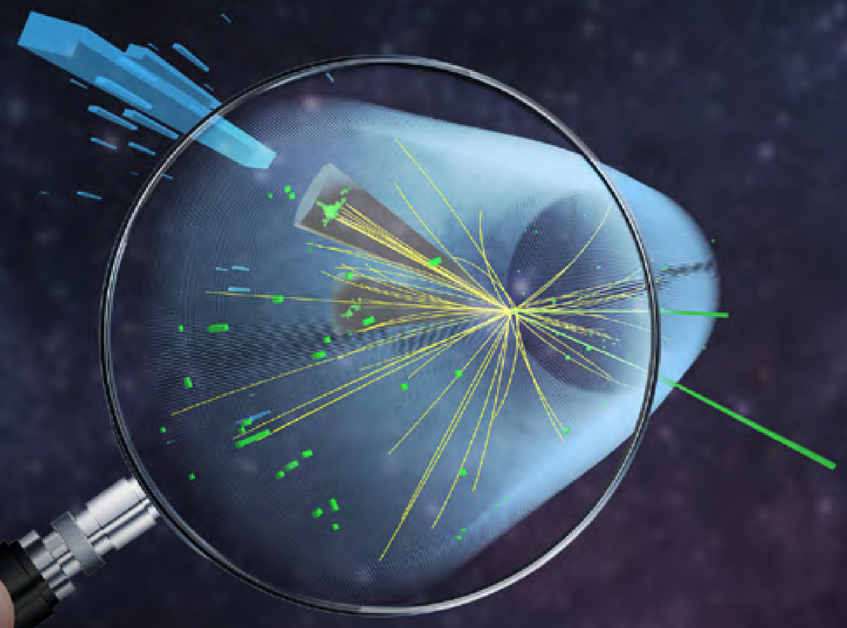
All Ages

NGSS Disciplinary Core Idea

- PS1 Matter and Its Interactions

NGSS Science and Engineering Practice

- Asking Questions and Defining Problems



Try This! How Small Is Small?

Take a close look at this page. What is the smallest detail you can see? It looks like a smooth piece of paper with solid lettering. Now look at this page with the camera of a smartphone. Zoom in as much as possible. Does it still look like a smooth piece of paper with solid lettering?

When we take a close-up look at the world we find that things look very different from how they appear on the surface. A camera can only zoom in so far before we need other tools, like microscopes and **particle accelerators**. Zooming in with these tools takes us to the atomic and subatomic scales, where things don't just look different—they act different.

What to Do

List three of the smallest things you can think of:

1. ______________________________
2. ______________________________
3. ______________________________

Compare your list with a partner's list. Put both your lists into one and order the items from largest to smallest.

Go Further!

Visit Quantum to Cosmos at **quantumtocosmos.ca**. Look for the objects on your list. What is the smallest object you can find?

All Ages

NGSS Disciplinary Core Idea

- ESS1 Earth's Place in the Universe

NGSS Science and Engineering Practice

- Asking Questions and Defining Problems

Try This! How Big Is Big?

The universe is big—very big. There is nothing bigger.

Go outside on a clear night and look up at the sky. What do you see? Did you know that as you gaze up at the stars you are traveling back in time? The light that hits your eyes left those stars many years ago. What you see is what each star looked like when its light left on its voyage to Earth.

Light travels 300 000 km every second. Even at this incredible speed it can take a long time for light to reach us because the universe is so huge. This gives us a natural time machine! Looking farther and farther away lets us look further and further back in time. Astronomers have been able to use telescopes to collect light that has traveled for 13.7 billion years.

What to Do

Go outside on a clear night and find the Big Dipper. If you need help, use a sky chart app such as SkyView.

Find Dubhe, the bright star at the tip of the spoon. It is 123 **light years** away. That means the light traveled for 123 years before it reached your eye.

Go Further!

Imagine that there is an alien civilization on a planet near Dubhe. If the aliens pointed a telescope at Earth, what would they see? Would they see you?

All Ages

NGSS Disciplinary Core Idea

- ETS1 Engineering Design

NGSS Science and Engineering Practice

- Asking Questions and Defining Problems

Design Challenge: Make a Mystery Tube

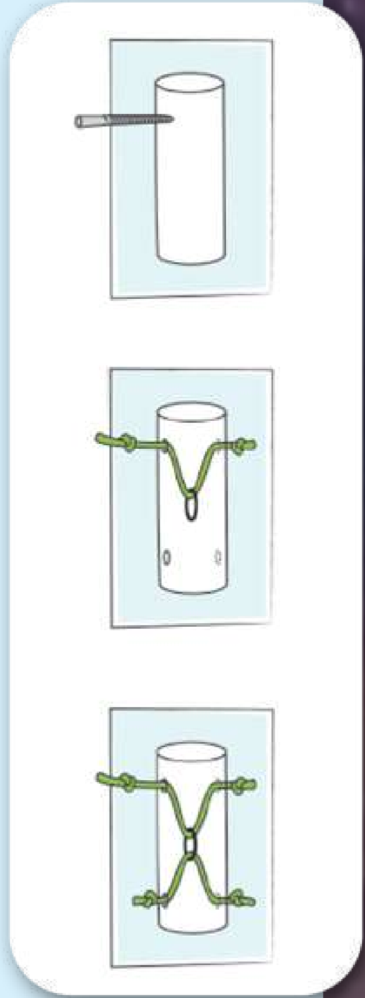
Science is about building models to explain our observations. Good models explain observations and make predictions for new ones. Make a mystery tube with a toilet paper tube and string. Challenge your friends to come up with a model to explain how the strings are connected.

Materials

- toilet paper tube
- toothpick or sharp pencil
- string
- washer (optional)
- 2 elastic bands
- parchment paper

What to Do

1. Using a toothpick or pencil, poke two holes directly across from each other 2 cm from the top of the toilet paper tube. Repeat to make the bottom two holes. Thread a piece of string through a top hole, through the washer (if you choose) and through the other top hole.
2. Thread a second piece of string through a bottom hole and connect it to the top string using one of several methods. For example, you can thread it through the washer as shown, or loop one string over the other.
3. Close the ends of the tube with parchment paper and elastic bands. Put a knot at each end of the strings to prevent them from slipping into the tube.



Pull on the strings and have a parent or friend watch. Ask them to think like a scientist. Can they suggest how the strings might be connected? What model would explain what they see? Can they come up with more than one model to explain the observations?

Go Further!

Often there is more than one model that can explain observations. We can only rule out a model with careful tests. This has happened in history many times. Research a scientific model that was ruled out. Why was it ruled out?

All Ages

Puzzle: The History of the Universe in One Year

Look at the Timeline of the Universe on pages 14 and 15. Imagine that we compressed the history of the universe—all 13.8 billion years of it—into one year. Each month would represent just over a billion years. If the Big Bang happened during the first second of New Year's day, when would the following events happen? Draw a line to match each of the events to the right date.

- FIRST HUMANS APPEAR
- FIRST STARS APPEAR
- THE BIG BANG
- LIFE APPEARS ON EARTH
- MASS EXTINCTION OF DINOSAURS
- MILKY WAY GALAXY FORMS
- FIRST DINOSAURS APPEAR
- SOLAR SYSTEM AND EARTH FORM
- FIRST GALAXIES FORM
- FIRST MAMMALS APPEAR

All Ages

Word Search: Secrets of the Universe

B P Z U U V J F E N Q U A N T U M M N X D L P T C
T Y B S P U L J L X E G W A Y K H P N N G M S R T
C S E G A U J G M U O L J X E X J D P P O G U C Y
N N P E R I M E T E R P O I D P L R K R C N Z V X
F F O P T P U I F R X N L H E S R P E U D A H E Z
L L C S I Q Z L H T G V U A K O Z G N R J B P R H
L T S O C R L M O V K P M H N C G B Z A T G W A D
Y F E M L S I R G Q E K H N B E A I B E Y I U T I
R E L S E U T I V F H F Z K A N T L L Y D B S P E
O L E O S N N F P Y W A F Z Z E N L B T U C D A T
Z N T C R I B I J S A J T D L D X N T H S L C H W
J D Z Q H N G L V M E J Q D M B K L N G S C V U Q
R U D K K F H Y S E Z X S M T P N Y N I E A X S V
U S M Q R Y V A U S R V W J D C R R J L G U N M T
C E I C Y P L G L B Z S R Z U U C N E V A H T K X
Q W Y N E P M J R K N E E A P H A R R C L U B M E
P G I B A U C V G Y D E X A F Q A Z X F A L D C I
I C J L H M Q I P S J Q K Q Y T K G P N X Q D Q K
J C P V V W Q T H O O K H S O W F D Q Z Y J T W S
G X P C Q D Z I Y G Y T R R E A K Y G R V M V K A
S J G Y J F F J S Q U R E D I L L O C V M G P X W
L L U N F T W S I N K K V K Z M Q Q U A R K W S I
L G V E Z U O Y C O O T C P F D G C A S R A T S Q
Z Z J S L D F T S B A Q A P E Q R P I O O M S S D
T X L E Q L X S W A Q H G C B T I W T L A Y N Q A

ACCELERATOR
BIG BANG
BLACK HOLE
CERN
COLLIDER
COSMOS
EXOPLANET
GALAXY
LIGHT YEAR
LIGO
PARTICLE
PERIMETER
PHYSICS
PLASMA
QUANTUM
QUARK
REDSHIFT
STARS
TELESCOPE
UNIVERSE

Next Generation Science Standards Connections

	What's That Sound?	Why Put a Telescope in Space?	Learning with Light	Sparking Curiosity	Expansion and Cooling	Discover Redshift	Why Is the LHC So Big?	Find an Exoplanet with Your Smartphone	How Small Is Small?	How Big Is Big?	Make a Mystery Tube
Disciplinary Core Ideas											
PS1 Matter and Its Interactions			5–8	5–8					All Ages		
PS2 Motion and Stability: Forces and Interactions							9–12				
PS3 Energy					5–8		9–12				
PS4 Waves and Their Applications in Technologies for Information Transfer	K–4	K–4	5–8			9–12		9–12			
ESS1 Earth's Place in the Universe					5–8	9–12		9–12		All Ages	
ETS1 Engineering Design											All Ages
Science and Engineering Practices											
Asking Questions and Defining Problems	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Developing and Using Models					✓	✓		✓			✓
Planning and Carrying Out Investigations	✓	✓	✓			✓	✓			✓	✓
Crosscutting Concepts											
Patterns	✓			✓		✓		✓	✓		✓
Cause and Effect	✓	✓	✓	✓	✓	✓	✓	✓			✓
Scale, Proportion, and Quantity				✓			✓		✓	✓	✓
Energy and Matter	✓	✓	✓		✓	✓					
Interdependence of Science, Engineering, and Technology		✓	✓				✓		✓	✓	✓

More to Explore

Resources for Teachers

Find the following free educational resources at **www.perimeterinstitute.ca/resources**:

HS = high school, MS = middle school, E = elementary

- **Beyond the Atom** (HS)
- **Black Holes** (HS)
- **Discovering Gravitational Waves** (HS)
- **Figuring Outer Space** (MS/HS)
- **It Does Matter** (E/MS)
- **Mission Possible** (E/MS)
- **Process of Science** (E/MS/HS)
- **The Expanding Universe** (HS)

Videos

Seeing the Smallest Thing in the Universe
www.youtube.com/watch?v=6leeshkVATY

How Does the Large Hadron Collider Work?
www.youtube.com/watch?v=oWpy0SAAI6E

Brief Guide to the Galaxy
www.youtube.com/watch?v=dXzQficJuiA

How to Find an Exoplanet
www.youtube.com/watch?v=AnX7ExBjrHw

How Do We Learn About a Planet's Atmosphere?
www.youtube.com/watch?v=W1bel0ODIDE

Alice & Bob in Wonderland: Is That Star Really There?
www.youtube.com/watch?v=F2VOMnVyY1s

Gravitational Waves Explained Using Stick Figures
www.youtube.com/watch?v=YHS9g72npqA

A Universe of Waves
www.youtube.com/watch?v=E2n7MTlmoVM

Websites

Secrets of the Universe
www.secretsoftheuniversefilm.com

Quantum to Cosmos Interactive
www.quantumtocosmos.ca/

James Webb Space Telescope
www.jwst.nasa.gov/

LIGO
www.ligo.caltech.edu/

LHC
home.cern/science/accelerators/large-hadron-collider

Answers to Puzzle: The History of the Universe in One Year

The Big Bang .... January 1
First stars form .... January 3
First galaxies form .... January 22
Milky Way galaxy forms .... March 16
Solar system and Earth form .... September 2
Life appears on Earth .... September 14
First dinosaurs appear .... December 25
First mammals appear .... December 26
Mass extinction of dinosaurs .... December 30
First humans appear .... December 31

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978-1-989069-28-8	Secret of the Universe: K-12 Educator's Guide	Book