

## Unit Plan for COSMOLOGY - Big Bang and Origin of the Universe in NGSS Physics

<b>Discipline:</b>	Physics
<b>Topic:</b>	Cosmology
<b>Related PE(s):</b>  <a href="#">HS-ESS1-2</a>	<ul style="list-style-type: none"> <li>• <a href="#">HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. [Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).]</a></li> </ul>
<b>DCI's</b>	<p><b>ESS1.A: The Universe and Its Stars</b></p> <ul style="list-style-type: none"> <li>• <u>The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.</u></li> <li>• <u>The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe.</u></li> <li>• <u>Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.</u></li> </ul> <p><b>PS4.B: Electromagnetic Radiation</b></p> <ul style="list-style-type: none"> <li>• <u>Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (secondary)</u></li> </ul>
<b>Phenomena</b>	Images and data gathered from galaxies Redshift
<b>Essential Questions</b>	<p>Explain: What is the Big Bang Theory? What sources provide astronomical evidence that support the Big Bang theory?</p> <p>Interpretation: What is the meaning of a redshift vs distance plot and how does it relate to the Big Bang theory?</p> <p>Perspective: Is the astronomical evidence reliable? Sufficient? How can you/scientists get better astronomical data?</p> <p>Empathy: If the Big Bang goes against someone else's beliefs, how might we communicate and reach an understanding about the scientific process supporting the theory?</p>

**Evidence Statements for HS-ESS1-2**

<b>Observable features of the student performance by the end of the course:</b>	
<b>1</b>	<b>Articulating the explanation of phenomena</b>
	<p>a Students construct an explanation that includes a description* of how astronomical evidence from numerous sources is used collectively to support the Big Bang theory, which states that the universe is expanding and that thus it was hotter and denser in the past, and that the entire visible universe emerged from a very tiny region and expanded.</p>
<b>2</b>	<b>Evidence</b>
	<p>a Students identify and describe* the evidence to construct the explanation, including:</p> <ul style="list-style-type: none"> <li>i. The composition (hydrogen, helium and heavier elements) of stars;</li> <li>ii. The hydrogen-helium ratio of stars and interstellar gases;</li> <li>iii. The redshift of the majority of galaxies and the redshift vs. distance relationship; and</li> <li>iv. The existence of cosmic background radiation.</li> </ul>
	<p>b Students use a variety of valid and reliable sources for the evidence, which may include students' own investigations, theories, simulations, and peer review.</p>
	<p>c Students describe* the source of the evidence and the technology used to obtain that evidence.</p>
	<b>Reasoning</b>
<b>3</b>	<p>a Students use reasoning to connect evidence, along with the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future, to construct the explanation for the early universe (the Big Bang theory). Students describe* the following chain of reasoning for their explanation:</p> <ul style="list-style-type: none"> <li>i. Redshifts indicate that an object is moving away from the observer, thus the observed redshift for most galaxies and the redshift vs. distance relationship is evidence that the universe is expanding.</li> <li>ii. The observed background cosmic radiation and the ratio of hydrogen to helium have been shown to be consistent with a universe that was very dense and hot a long time ago and that evolved through different stages as it expanded and cooled (e.g., the formation of nuclei from colliding protons and neutrons predicts the hydrogen-helium ratio [numbers not expected from students], later formation of atoms from nuclei plus electrons, background radiation was a relic from that time).</li> <li>iii. An expanding universe must have been smaller in the past and can be extrapolated back in time to a tiny size from which it expanded.</li> </ul>

<b>Learning Objective (Knowledge)</b>	<b>Learning Objective (Skills)</b>
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<p>*describe/explain could be written, oral, pictorial, or kinesthetic</p> <p>SWBAT describe the composition of stars in terms of elements- that stars are made of hydrogen and helium and trace amounts of other elements (the same elements as we have on earth.)</p> <p>SWBAT describe that stars and interstellar gases throughout the universe have significantly more hydrogen than helium</p> <p>SWBAT describe that the Big Bang theory is the idea that the entire visible universe emerged from a single point and that is expanding.</p> <p>SWBAT describe the smaller size, greater density, and hotter temperature of the universe in the past.</p> <p>SWBAT explain how redshift and blueshift are indicators of galactic motion away from or toward an observer, using the speed of light in a vacuum.</p>	<p>SWBAT explain redshift and blueshift in terms of EM waves, either in words or pictorially.</p> <p>SWBAT explain how different pieces of evidence provide support for the Big Bang theory</p> <p>SWBAT critique a claim by making observations and collecting data, analyzing data graphically, and applying reasoning skills to support or negate claims of galactic motion.</p> <p>Specifically, SWBAT</p> <ul style="list-style-type: none"> <li>● Use best practices for collecting appropriate data.</li> <li>● Display data in an appropriate graphical form.</li> <li>● Make a best fit line of data if appropriate.</li> <li>● Make extrapolations and interpolations from a data set.</li> <li>● Develop a model based on evidence from data to illustrate the relationships between systems or between components of a system.</li> </ul> <p>SWBAT find appropriate sources for data to support or negate a claim about galactic motion (ie. Andromeda is moving away from or toward us).</p> <p>SWBAT plot data to show a trend, pattern, or relationship about galactic motion.</p> <p>SWBAT identify sources of error or areas of improvement for data collection related to galactic motion.</p> <p>SWBAT evaluate evidence behind currently accepted explanations or solutions related to galactic motion to determine the merits of arguments.</p> <p>SWBAT explain how the cosmic microwave background is used as evidence for the big bang energy.</p>
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## **Student Conduct Expectations and Classroom Rules**

<b>Expectations</b>	<b>Classroom Rules</b>
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1. Be Prepared	1. Show respect to EVERYONE
2. Participate	2. Listen carefully to instructions
3. Complete ALL assigned work by the due date	3. Follow directions
4. Ask questions relevant to the topic of discussion	4. Raise your hand to gain the attention of the instructor
	5. If you use it, you put it away correctly.

(Backwards Design format - Stage 1: Unit Goals, Stage 2: Evidence of learning/assessments, Stage 3: Daily lesson plans)

Stage 1 Desired Results	
ESTABLISHED GOALS	<i>Transfer</i>
<p>NGSS goal: HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. [Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).]</p>	<p><i>Students will be able to independently use their learning to...</i></p> <p>Critique a claim by making observations and collecting data, analyzing data graphically, and applying reasoning skills to support or negate the claim.</p> <p>Specifically, students will:</p> <ul style="list-style-type: none"> <li>Use best practices for collecting appropriate data.</li> <li>Display data in an appropriate graphical form.</li> <li>Make a best fit line of data if appropriate.</li> <li>Make extrapolations and interpolations from a data set.</li> <li>Develop a model based on evidence from data to illustrate the relationships between systems or between components of a system.</li> </ul>
	<i>Meaning</i>

	<p><b>UNDERSTANDINGS</b> <i>Students will understand that...</i></p> <p>(Overarching understanding) A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.</p> <p>(Overarching understanding) Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.</p> <p>(Overarching understandings from NGSS Connections to Nature of Science)</p>	<p><b>ESSENTIAL QUESTIONS- Label Facets</b></p> <p>Explain: What is the Big Bang Theory? What sources provide astronomical evidence that support the Big Bang theory?</p> <p>Interpretation: What is the meaning of a redshift vs distance plot and how does it relate to the Big Bang theory?</p> <p>Perspective: Is the astronomical evidence reliable? Sufficient? How can you/scientists get better astronomical data?</p> <p>Empathy: If the Big Bang goes against someone else's beliefs, how might we communicate and reach an understanding about the scientific process supporting the theory?</p>
<b>Acquisition</b>		

	<p><i>Students will know...</i></p> <p><i>NGSS DCIs</i> The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2),(HS-ESS1-3)</p> <p>The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (HS-ESS1-2)</p>	<p><i>Students will be skilled at...</i></p> <p>Finding appropriate sources for data to support or negate a claim.</p> <p>Plotting data to show a trend, pattern, or relationship.</p> <p>Identifying sources of error or areas of improvement for data collection.</p> <p>Evaluating evidence behind currently accepted explanations or solutions to determine the merits of arguments</p>
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**Stage 2 - Evidence**

<b>Evaluative Criteria</b>	<b>Assessment Evidence</b>
<p>Plot created with correct axis labeled, accurate title, and 5 or more data points with best fit line</p> <p>CER uses plot data to support a claim.</p> <p>Students come up with questions or suggestions for further study.</p> <p>Accuracy of content.</p>	<p>PERFORMANCE TASK(S):</p> <p>Students will gather galactic data using <u>multiple</u> interfaces for use in a lab assessment.</p> <p>Students will make a plot of redshift vs distance or redshift vs wavelength. Using this plot, students will explain evidence for the origins of the universe in CER (Claim, Evidence, Reasoning) form.</p> <p>Students can describe what the big bang is, and how it relates to the expanding universe.</p> <p>Students will make suggestions for improving an experiments or observations, such as gathering more data.</p> <p>Students can correctly rank objects in terms of their sizes in the universe.</p> <p>Students can identify emission and absorption lines ("peaks" and "valleys") in spectra</p>

<p>Plot is easy to read and done either on computer or with a ruler/straight edge.</p> <p>Grammar and spelling is accurate.</p> <p>Terms are used accurately.</p>	<p>OTHER EVIDENCE/Modifications:</p> <p>Student can explain redshift in their own words and give examples.</p> <p>Students can explain how theory and experiment come together to create scientific evidence</p> <p>Given astronomical objects of various magnitudes, students can make reasonable claims regarding brightness, and distance of the objects in the universe.</p>
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**Stage 3 – Learning Plan**

*Summary of Key Learning Events and Instruction*  
(Please review your goals to ensure you connect back to them.)

Pre-Assessment: Students will begin filling out a K-W-L chart by filling out the K and W portions on what students know about the Universe. Teacher will make heterogeneous groupings based on what students already know about the Universe.

\*Lessons are designed for four by four schedule with 90 minutes per lesson.

**Lesson 1: Size and Scale of the Universe (Background introduction, observations)**

Students will investigate the scale of the universe. Student will use NASA information to place markers on the school field to represent the size and scale of the solar system. ([https://www.nasa.gov/audience/foreducators/5-8/features/F\\_Solar\\_System\\_Scale.html](https://www.nasa.gov/audience/foreducators/5-8/features/F_Solar_System_Scale.html)) Teacher will guide students with questioning techniques if an object is misplaced. Students will make observations of the solar system size and make guesses based on their observations on the distances to stars and galaxies. Back in the classroom, “The Powers of Ten” video <https://youtu.be/vRjGarlCaI4> or the Scale of the Universe <https://www.youtube.com/watch?v=uaGEjrADGPA> can be shown or students may play with the simulation <http://scaleofuniverse.com/> if they have access to devices with Adobe Flash. Student may also wish to explore Khan Academy lesson and videos here:

<https://www.khanacademy.org/science/cosmology-and-astronomy/universe-scale-topic/scale-earth-galaxy-tutorial/v/scale-of-the-large>

Students will work in pairs to rank in size different objects in the universe (formative assessment - objects include moons, planets, stars, nebula, star clusters, galaxies, local group, galaxy clusters, and universe).

## **Lesson 2: Introduction to Cosmology Topics through the Sloan Digital Sky Survey Data (Background and Research)**

Students will be introduced to the evidence for the Big Bang Theory. Students will begin research on “The Universe Project” through the open data sources with the Sloan Digital Sky Survey (SDSS) located at this site here: <http://skyserver.sdss.org/dr1/en/proj/basic/universe/>. Teacher information for this project can be found here: <http://skyserver.sdss.org/dr1/en/proj/teachers/basic/universe/> and <https://docs.google.com/document/d/1CM1G2fOeHQ4grPwmCR0I2fjsHPOTD8h4A2L7alDREpo/edit?usp=sharing>. Students will work in pairs on Chromebooks to explore the galaxies and data in the SDSS database. Teacher will guide students with using the SDSS data interface, pointing out locations for redshift and magnitudes as needed. Students will begin to fill out the data table for the six chosen galaxies. Formative Assessment: Exercise 1, Question 1 are answered in concise and correct explanations. Data Table is correct and has appropriate and accurate labels. At least six galaxies are represented on data table.

## **Lesson 3: Continuation of SDSS Universe Project (Data analysis, observations, reasoning, reflect on metacognition)**

Perspective Essential Question: Is the astronomical evidence reliable? Sufficient? How can you/scientists get better astronomical data? Students will create a plot using Google Sheets from the Data Table they created yesterday. Teacher will assist students as needed for pointing out locations for tools such as how to change labels, scales, and showing best fit lines. Students continue in pairs with Exercises 4 and 5, making their Hubble Plots and writing a CER (Claim - Evidence - Reasoning) based on the trends and patterns they see in the graph. Pairs of students will share with the rest of the table and discuss ways scientists could improve the quality of data. Students will reflect on their metacognition by going back to the K-W-L chart and adding to all three columns and reflecting on how they have learned what they claim to have learned. Perspective Essential question will be discussed as a group. After the discussion, students will write their own individual answers to essential question. Formative assessments: Plots, CERs and essential question will be graded and given feedback.

## **Lessons 4: Evidence for Big Bang, Hubble, Spacetime, and Size, scale, and composition of the Universe (Problem-solving, imagining, thought experiments, interpretation, reflections)**

Teacher will give short lectures (no more than 15 mins) summarizing Cosmology topics - PPT for Cosmology lecture: [https://docs.google.com/presentation/d/1DfF3WCt590auYBlInFoaoww4oUtG7MCp\\_fSkwHv9xtNE/edit?usp=sharing](https://docs.google.com/presentation/d/1DfF3WCt590auYBlInFoaoww4oUtG7MCp_fSkwHv9xtNE/edit?usp=sharing). Students will Think-Pair-Share on the topics of redshift: What is a redshift? Are all galaxies redshifted? What is the meaning of a redshift vs distance plot and how does it relate to the Big Bang theory? Balloon analogy and tutorial. Students will be given balloons at their table and asked to draw dots on the balloons and measure the distance between dots. Then students will inflate their balloons and re-measure the distances between the dots.

## **Lesson 5: (continuation from Lesson 4) Evidence for Big Bang, Hubble, Spacetime, and Size, scale, and composition of the Universe (Problem-solving, imagining, thought experiments, interpretation, reflections)**

Teacher will give short lecture (no more than 15 mins) summarizing the rest of the Cosmology topics - PPT for Cosmology lecture: [https://docs.google.com/presentation/d/1DfF3WCt590auYBlnFoaoww4oUtG7MCp\\_fSkwHv9xtNE/edit?usp=sharing](https://docs.google.com/presentation/d/1DfF3WCt590auYBlnFoaoww4oUtG7MCp_fSkwHv9xtNE/edit?usp=sharing). Balloon analogy and tutorial. Students will use the lecture tutorial, "Expansion of the Universe", [https://drive.google.com/open?id=1\\_oiq8wcvDitGJs3skXsFQCB5xvllb1wP](https://drive.google.com/open?id=1_oiq8wcvDitGJs3skXsFQCB5xvllb1wP), and be given balloons at their table and asked to draw dots on the balloons and measure the distance between dots. Then students will inflate their balloons and re-measure the distances between the dots. Students will work in pairs to use this balloon analogy to discuss the model of the universe, and share their answers to the questions on the lecture tutorial, "Expansion of the Universe", [https://drive.google.com/open?id=1\\_oiq8wcvDitGJs3skXsFQCB5xvllb1wP](https://drive.google.com/open?id=1_oiq8wcvDitGJs3skXsFQCB5xvllb1wP). Students will vote on question 12 as a class and volunteers will be asked to explain their reasoning aloud.

### **Lesson 6: Evaluation and Reflection**

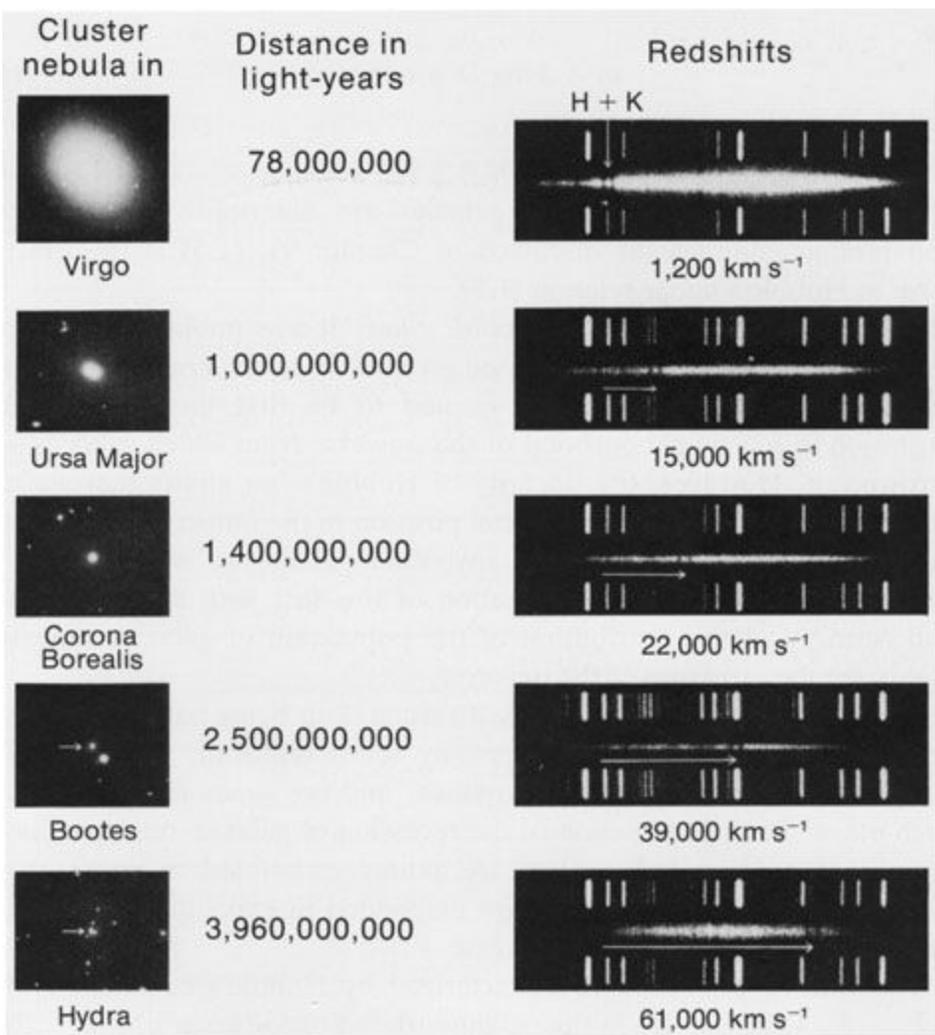
Explain: What is the Big Bang Theory? What sources provide astronomical evidence that support the Big Bang theory?

Empathy: If the Big Bang goes against someone else's beliefs, how might we communicate and reach an understanding about the scientific process supporting the theory?

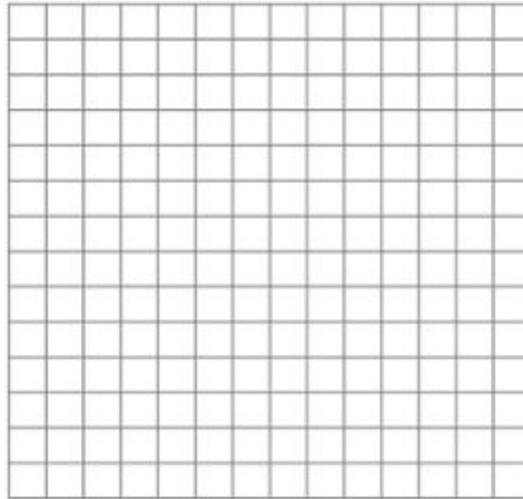
Students will review their K-W-L chart and reflect on what they learned and how they were able to learn it. In the heterogeneous groups of four, students will share their reflections as well as share one new question that they have that still remains. The Explain and Empathy Essential questions will be discussed in these small groups with a couple selected to share to start a discussion with the whole class.

**Lesson 7: GRASPS individual summative assessment:** Students will each be given galactic data from five different galaxies (note - students will not get the same galaxies; there will be several versions of this assessment). Students will be asked whether this data supports the findings of Hubble by plotting the relevant data, showing whether it fits a trend, and explaining how the plot either does or does not support the expanding universe model.

**Example GRASPS assessment:** You are working for NASA and are given the following galactic data:



Your job is to figure out if the data supports the findings of Hubble. Your boss asks you to generate a graph to understand the data. Plot the relevant data on the graph below, making sure to label the axes correctly.



Does your data show a trend?  
Explain.

Does the plot support the expanding universe model? Explain with CER (Claim - Evidence - Reasoning).

[CER Rubric](#)