

Diffraction Unit, Lesson 5: The Red Universe

Redshift and the Expanding Universe

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Grade Level	10th – 12th Grade
Subject	Science
Course	Physics

Essential Question

What evidence do we have that objects in the universe are moving away from us?

Summary

This is the fifth and final lesson in the Diffraction Unit. In this lesson, students will apply the Doppler Effect to electromagnetic waves, and examine redshift as evidence of the expanding universe.

Snapshot

Engage

Students watch a video on how a police radar gun works and answer questions.

Explore

Using the GUS instructional strategy, students work in groups to answer questions about shift in color. Students watch a video about redshift and complete an activity using the Caption This instructional strategy.

Explain

Students use the Appointment Clock instructional strategy to answer questions and solve equations.

Extend

Students use the Triangle of Power instructional strategy to answer questions and solve equations.

Evaluate

Students write a Two-Minute Paper supporting the following statement: “Objects in the Universe are moving away from each other.”

Standards

Next Generation Science Standards (Grades 9, 10, 11, 12)

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.

Oklahoma Academic Standards (Chemistry)

CH.PS4.3 : Develop an argument for how scientific evidence supports the explanation that electromagnetic radiation can be described either by the wave model or the particle model, and in some situations one model is more useful than the other.

Oklahoma Academic Standards (Chemistry)

PH.PS4.1 : Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
PH.PS4.5 : Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.*

Attachments

- Beyond Red Teacher's Guide—The Red Universe.docx
- Beyond Red—The Red Universe.docx
- Lesson Slides—The Red Universe.pptx
- Radar Video Questions Teacher's Guide—The Red Universe.docx
- Radar Video Questions—The Red Universe.docx
- Redshift in Absorption Spectra Teacher's Guide—The Red Universe.docx
- Redshift in Absorption Spectra—The Red Universe.docx
- Shifting Colors Teacher's Guide—The Red Universe.docx
- Shifting Colors—The Red Universe.docx

Materials

- Lesson slides (attached)
- Radar Video Questions handout (attached, one per student, print 2-sided)
- Radar Video Questions Teacher’s Guide handout (attached, optional)
- Shifting Colors handout (attached, one per group, print 1-sided)
- Shifting Colors Teacher’s Guide handout (attached, optional)
- Redshift in Absorption Spectra handout (attached, one per student)
- Redshift in Absorption Spectra Teacher’s Guide handout (attached, optional)
- Beyond Red handout (attached, one per group, print 1-sided)
- Beyond Red Teacher’s Guide handout (attached, optional)
- Science notebooks
- Graphing paper (1 per student)
- White balloons (1 per every 2 students)
- Permanent markers (black, 1 per every 2 students)
- Notebook paper (optional)
- Graphing calculators (optional)

25 minutes

Engage

Teacher's Note: Before Teaching this Lesson

During the Engage portion of this lesson students will be referring back to information they learned in Diffraction Unit, Lesson 3: Wonky Waves. If you have not previously taught your students about the Doppler effect, consider teaching that lesson first.

Use the attached **Lesson Slides** to present the lesson.

Display **slides 1-4** to introduce the lesson, essential question, and learning objective.

Display **slide 5.** Have students read the statement on the slide. Give students a minute to decide if they agree or disagree with the statement. Have students discuss the statement with an elbow partner first. Next, ask for a few volunteers to share their opinion about why they agree or disagree.

Display **slide 6** and ask students about what they remember about the Doppler effect from Lesson 3: Wonky Waves. Have a few students share what they remember. If students struggle with answering, encourage them to review the information on the slide. Emphasize the fact that wavelengths increase as objects are moving away from the observer and decrease as objects move away from the observer.

Display **slide 7** and pass out the **Radar Video Questions** handout. Inform students that they will be watching a video that explains how a radar gun works. Using the image on the handout and students' prior knowledge tell students they will have 10 minutes to answer questions 1-6 on the front of the handout, which they will do by using their prior knowledge. Depending on the needs of your students, have them work independently or in small groups. Students can write their answers on the handout or in their Science notebook. If a student is unsure of an answer, have them skip the question and look for the answer in the video. Start the 10 minute timer and allow students to work through the questions.

Display **slide 8** and inform the students that they will now answer questions 7-13 on the back of the handout independently as they watch the video. Remind them to answer any skipped questions or adjust answers on the front of the handout. Begin the video How Police Radar Guns Work.

Embedded video

https://youtube.com/watch?v=DAwW7_nYG0c

Teacher's Note: Video Correction

The math equation in the video should have a 2 in the denominator. Have students note this change.

Once the video is over, discuss the answers to the questions before and after the video as a class. Call on volunteers to share their answers and encourage students to make any necessary corrections.

Collect the student's answers.

20 minutes

Explore

Teacher's Note: Teacher's Guide

Use the attached **Shifting Colors Teacher's Guide** handout to help guide the activity.

Put students into groups of three. Display **slide 9** and introduce the GUS Method instructional strategy. Explain to the class that as they work with their group to answer questions they will label each question with either a G, U, or S. The G represents that their answer was a guess, U represents an answer they are unsure about, and S represents an answer the students are sure about and are able to explain. Emphasize to the class that it is okay to guess or be unsure of an answer and that you will be reviewing the questions at the end of the activity.

Display **slide 10** and pass out the attached **Shifting Colors** handout to each group. Have students in each group take on a role as a reader, recorder, or reporter. The reader will read the text from page 1 of the handout, the recorder is responsible for recording the answers from page 2 of the handout, and the reporter will share out with the group. Have the recorder write the answers down in a science notebook or on a sheet of notebook paper, but have them label the questions with G, U, or S on the handout. Provide groups time to complete the handout.

Teacher's Note: During the Activity

As the groups are working on the handout, walk around and pay attention to the questions students mark with G or U. Consider using these questions as the whole class discussion. Also, collect the handouts once the activity is complete and use the labels on the questions to make a determination as to if the class or a group of students need more review on a question.

Once each group has completed the handout, come back as a whole class. Select a few questions from the handouts to discuss as a class. Ask different group reporters to share answers to questions.

Display **slide 11**. Inform students that they will watch a video about redshift in galaxies. Explain to students that they will complete an activity using the information they learned in the video. Show the video Redshift of Distant Galaxies.

Embedded video

https://youtube.com/watch?v=RO4i_g6gSMU

Display **slide 12** and introduce the Caption This instructional strategy. Put students into pairs. Inform them that with their partner they will discuss a 1-3 sentence caption that best represents the image on the slide and what they learned from the video. Provide students time to discuss what a good caption for the image would be. Ask for volunteers to share the caption they chose and why. Ask if any groups had a different caption.

This is a good point to end day 1.

25 minutes

Explain

If needed, review the essential question and learning objective before starting day 2.

Teacher's Note: Teacher's Guide

Use the attached **Redshift in Absorption Spectra Teacher's Guide** handout to help guide the activity.

Display **slide 13** and introduce the Appointment Clock instructional strategy. Pass out the attached **Redshift in Absorption Spectra** handout to each student. Inform the student that they will be rotating through four sets of partners to answer the questions from the handout and recording their answers in their science notebooks. Give students two minutes to find four different partners and write their names down on the top of the second page. As students finish filling out their appointment clocks, have them find their 12 o'clock partner, sit down, and wait for directions.

Once all groups have found their partners display **slide 14**. Have students work with their 12 o'clock partners to answer questions 1 and 2. Provide partners with about 5 minutes to answer the question. The 12 o'clock group and 3 o'clock group might finish faster. Consider having each group give you a thumbs up when they have completed the required questions. Once ready, have students rotate to their 3 o'clock appointment and answer questions 3 and 4. When groups have completed answering the questions, have them rotate to their 6 o'clock appointment to answer questions 5-7 and then their 9 o'clock appointment to answer questions 8-10.

Once all groups are done, come back together as a whole class. Select a few questions, including questions 8 and 9, to review as a class. Ask for volunteers to share out their answers.

50 minutes

Extend

Teacher's Note: Teacher's Guide

Use the attached **Beyond Red Teacher's Guide** handout to help guide the activity.

Put students into groups of three. Display **slide 15** and pass out the attached **Beyond Red** handout to each group. Introduce the Anticipation Guide instructional strategy to the class. Have students look at questions 1-4 on the top of page two of their handout. As a group, they will discuss the questions and write agree or disagree in the margin next to each question.

Once each group has completed recording agree or disagree for the first 4 questions, display **slide 16**. Introduce students to the Triangle of Power instructional strategy. Explain that the Triangle of Power can be used to complete any $a = b\ (c)$ equation that they encounter.

Display **slide 17** and have students work in their groups to use the Triangle of Power instructional strategy to solve questions 5-12 in their Science Notebooks. Pass out graph paper to each student or have them use a graphing calculator.

Once each group has completed the handout either go over the equations as a class or collect their Science Notebooks to review.

Have students say in their groups of 3 and display **slide 18**. Remind students about the Caption This instructional strategy. As a group the students will examine the image on the slide. They will discuss a 1-3 sentence caption that best represents the image and what they have learned so far. Provide students time to discuss what a good caption for the image would be. Ask for volunteers to share the caption they chose and why. Ask if any groups had a different caption.

This is a good point to end day 2.

If needed, before beginning day 3, review the essential question and learning objective.

Display **slide 19**. Have students find a partner. Pass out one white balloon and one permanent marker for each group. Have students complete the following steps:

1. Draw objects, stars, or galaxies all over the deflated balloon.
2. Discuss with your partner how close the objects you drew are in relation to each other.
3. Blow up the balloon and tie it closed.
4. With your partner make observations about the objects you drew and how they moved in relation to each other.

Teacher's Note: Alternate Activity

The balloon activity can be done as a teacher demonstration.

Display **slide 20** and, as a class, discuss what students noticed when they blew up the balloons.

Display **slide 21** and inform the students they will watch a video about the James Webb Telescope . Show students The Power of the James Webb Telescope video. End the video at 4:57 minutes. Once you stop the video ask students what they connected from the video to what they have learned the past few days.

Embedded video
https://youtube.com/watch?v=U4BCk8OdHSA

Display **slide 22** and inform the student that they will now be watching a video that compares the James Webb telescope with the Hubble telescope. Show students the James Webb vs Hubble Telescope Images Comparison video. Once the video is complete discuss whether students believe that the James Webb or Hubble is the better telescope and why.

Embedded video
https://youtube.com/watch?v=97E4kcbNV8g

Evaluate

Display **slide 23** and introduce the Two-Minute Paper instructional strategy. Let the students know that they will have 2 minutes to write a short paper to support the statement:

Objects in the Universe are moving away from each other.

Encourage students to use their science notebook and any other resources to help, but remind them that 2 minutes isn't a very long time. Pass out notebook paper or have students write in their science notebooks. Start the timer on the slide.

Embedded video

https://youtube.com/watch?v=HcEEAnwOt2c

Teacher's Note: Two-Minute Paper

Students could also create models to complement their writing in their paper, but remind them that they need to monitor their time.

Once the timer is complete, collect students' papers or science notebooks to review. If time allows, have a class discussion about the statement on the slide.

Resources

Diffraction Unit, lesson 3: Wonky waves. K20 LEARN | Diffraction Unit, Lesson 3: Wonky Waves. (n.d.). https://learn.k20center.ou.edu/lesson/2440

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YouTube. (2016, January 7). How police radar guns work. YouTube. https://www.youtube.com/watch?v=DAwW7_nYG0c

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YouTube. (2019, December 9). *The power of the James Webb Telescope*. YouTube. https://www.youtube.com/watch?v=U4BCk8OdHSA