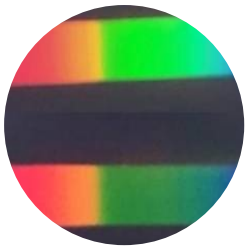

Light Absorption and Solar Spectra

Light Absorption and Stars

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Grade Level	8th – 12th Grade	**Time Frame**	2-4 class period(s)
Subject	Science	**Duration**	150 minutes
Course	Chemistry, Earth Science, Physical Science, Physics		

Essential Question

What is light absorption and how does this phenomenon help scientists identify stars that harbor planets that could support life?

Summary

Students will explore the phenomena of light absorption by viewing spectra of sunlight reflected off of different colors of paper. They will match absorption lines created by elements to absorption lines in sun spectra to reveal elements absorbing light in the sun. They will compare the sun's spectrum to the spectrum of another star to generalize what spectra and element absorption can teach about stars.

Snapshot

Engage

Students explain the phenomenon that different clothing colors retain heat differently and are introduced to absorption and reflection to explain this. Students also learn about tools used to observe light from the sun and consider physical properties that would allow a star to harbor a planet that could support life.

Explore

By assessing the temperature and recording the spectra of light reflected off of different colors of paper laying in the sun, students explore absorption. Students use a database of element absorption to correlate light absorption from specific elements to absorption lines observed in solar spectra.

Explain

Students explain (a) absorption differences for papers and clothing of varying color, (b) atomic-level mechanics and energetics of absorption, and (c) the extent to which absorption lines allow the elemental composition of stars to be assessed from a distance.

Extend

Students compare the spectra of the sun and Vega to generalize similarities and differences in star spectra. Students can be offered four different research extensions to further explore the search for planets capable of supporting life, practice quantitative calculations with an Algebra I level equation, engineer an improved spectrophotometer, or study biological examples of absorption.

Evaluate

Students can write a "two-minute paper" to reflect on a summary prompt provided by the teacher, provide formative assessment using the Muddiest Point activity to clear up incomplete understanding, and/or participate in the Gallery Walk strategy to share answers to Extend questions.

Standards

ACT College and Career Readiness Standards - Science (6-12)

IOD201: Select one piece of data from a simple data presentation (e.g., a simple food web diagram)
IOD202: Identify basic features of a table, graph, or diagram (e.g., units of measurement)
IOD301: Select two or more pieces of data from a simple data presentation
IOD402: Compare or combine data from a simple data presentation (e.g., order or sum data from a table)
IOD403: Translate information into a table, graph, or diagram
IOD404: Perform a simple interpolation or simple extrapolation using data in a table or graph
IOD502: Compare or combine data from a complex data presentation
IOD504: Determine and/or use a simple (e.g., linear) mathematical relationship that exists between data
IOD603: Perform a complex interpolation or complex extrapolation using data in a table or graph
SIN201: Find basic information in text that describes a simple experiment
SIN202: Understand the tools and functions of tools used in a simple experiment
SIN502: Predict the results of an additional trial or measurement in an experiment
SIN503: Determine the experimental conditions that would produce specified results
SIN702: Predict the effects of modifying the design or methods of an experiment
EMI301: Identify implications in a model
EMI401: Determine which simple hypothesis, prediction, or conclusion is, or is not, consistent with a data presentation, model, or piece of information in text
EMI402: Identify key assumptions in a model
EMI504: Determine which models are supported or weakened by new information
EMI505: Determine which experimental results or models support or contradict a hypothesis, prediction, or conclusion
EMI702: Determine whether presented information, or new information, supports or contradicts a complex hypothesis or conclusion, and why

Oklahoma Academic Standards (Physics)

ES.ESS1.3 : Construct an explanation about the process that causes stars to produce elements throughout their life cycle.
ES.ESS2: The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.
ES.ESS1.3.2: Other than the hydrogen and helium formed at the time of formation, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy.

Oklahoma Academic Standards (Physics)

PH.PS4.4 : Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.
PH.PS4.4.DCI.1: When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat).
PH.PS4.4.DCI.2: Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.
PH.PS4.4.DCI.3: Photoelectric materials emit electrons when they absorb light of high enough frequency.

Attachments

- Absorption-Lines-for-Eight-Elements-Data-Light-Absorption-and-Solar-Spectra - Spanish.docx
- Absorption-Lines-for-Eight-Elements-Data-Light-Absorption-and-Solar-Spectra - Spanish.pdf
- Absorption-Lines-for-Eight-Elements-Data-Light-Absorption-and-Solar-Spectra.docx
- Absorption-Lines-for-Eight-Elements-Data-Light-Absorption-and-Solar-Spectra.pdf
- Lesson-Slides-Light-Absorption-and-Solar-Spectra.pptx
- Representative-Data-for-Teacher-Reference-Light-Absorption-and-Solar-Spectra.docx
- Representative-Data-for-Teacher-Reference-Light-Absorption-and-Solar-Spectra.pdf
- Sample-Responses-for-Teacher-Reference-Light-Absorption-and-Solar-Spectra.docx
- Sample-Responses-for-Teacher-Reference-Light-Absorption-and-Solar-Spectra.pdf

- Student-Activity-Handout-Light-Absorption-in-Solar-Spectra - Spanish.docx
- Student-Activity-Handout-Light-Absorption-in-Solar-Spectra - Spanish.pdf
- Student-Activity-Handout-Light-Absorption-in-Solar-Spectra.docx
- Student-Activity-Handout-Light-Absorption-in-Solar-Spectra.pdf

Materials

- Lesson Slides (attached)
- Student Activity handout (attached; one per student)
- Absorption Lines for Eight Elements Data (attached; one per group)
- Representative Data for Teacher Reference (attached)
- Sample Responses for Teacher Reference (attached)
- Project STAR Spectrometer (available in our kit or can be purchased from several vendors; preferably one per group of 1–3 students)
- White paper, matte finish (one piece per group)
- Different colors of paper, solid colors and matte finish (at least two different colors per group)
- Colored pencils, pens, markers, or crayons for recording observations in color
- Student computers (optional)
- Wifi

Engage

Use the attached **Lesson Slides** to guide students through the lesson. Edit, add, or omit slides to suit your needs.

Teacher's Note: Time Management Options

For typical 45–60 minute classes, you will probably need one lesson to run through Engage and Explore Part A. You might have time at the end of the class for students to share drawings or photos of the spectra as an exit activity. You could also ask groups that worked faster to start answering Explain Part A questions. Day 2 is likely to begin with Part B of the Explore and then you should have time for work on Explain questions. A discussion of the Explain questions could occur at the end of Day 2 or the start of Day 3. Time needed for the Expand and Evaluate phases can be varied with the questions and activities you choose to include.

Teacher's Note: Setup And Considerations Before Class

(1) Go outside on a bright, sunny day for this activity. Reschedule if the day is cloudy.

(2) Absorption lines are easier to see if you use high quality spectroscopes or spectrometers. Diffraction gratings and lower quality spectroscopes do not reveal the black absorption lines as well. Through the OU Physics RET in collaboration with K20, you could arrange to borrow a set of "Project STAR" spectrometers for the activity. Group sizes (ideally 1–3 students) will be dictated by your supply of spectrometers.

Display **slide 2** to introduce the lesson title.

Move to **slide 3** and share the essential question with your students: *What is light absorption and how does this phenomenon help scientists identify stars that harbor planets that could support life?*

Move to **slide 4** and share the lesson's learning objectives with your students:

- Explore the phenomena of light absorption by viewing the spectrum of the sun reflected off of different colors of paper.
- Analyze data to identify elements that absorb light in the sun and learn about the importance of this absorption.
- Compare light spectra from two stars to learn more about how spectra are used to categorize stars.

Teacher's Note: Additional Background/Rationale for This Activity

The key goals are:

(1) Explore light absorption and work through the mechanics and energetics of light absorption at the atomic level.

(2) Observe and compare the spectra of the sun and Vega to introduce the role absorption lines play in star characterization, which helps astronomers search for habitable planets around distant stars.

(3) Optionally extend to engineering, quantitative calculation, and biological applications. Light absorption is a critical aspect of spectroscopy—an important scientific tool broadly used in biology, chemistry, physics, and earth and space science.

Distribute pages 1-2 of the **Student Activity Handout** to each student. (It can be advantageous to wait to distribute page 3 because Part A is about acquiring data shown on page 3.) Ask students to spend a few minutes answering the Engage questions individually or with Elbow Partners (perhaps as a bellringer). Then, use **slides 5–7** to briefly discuss the Engage questions and prepare students for the Explore phase.

Optional Reading To Add Depth To Engage Question #3

This brief reading introduces the idea of star categorization and describes attributes of stars that increase the odds that an orbiting planet could sustain life: https://earthsky.org/space/goldilocks-stars-g-k-dwarfs-best-for-alien-life

Explore

For Part A of Explore, put students in groups, distribute spectrometers/spectroscopes, and clarify that the goal is to look at light reflected off of different colors of paper to view and document spectra. Remind students to look for the rainbow spectra (introduced in Engage).

SAFETY NOTE: DO NOT DIRECTLY VIEW THE SUN

Remind students to **NOT** directly view the sun. Instead, they should be looking at the light REFLECTED off of the papers. This should have been covered during the discussion of Engage question #4 using **slide 7**.

Circulate among student groups to make sure they can see and are documenting the rainbow spectra. Ensure each group member gets a turn using the spectrometer. Consider allowing students to use phone cameras to record images of the spectra.

Teacher's Note: Tips for Gathering Data in Part A

(1) Like all spectroscopes, the Project STAR spectrometer may require a little practice to use, but if students have successfully viewed flame tests or gas emission spectra before, then the bright, full spectra observed here are relatively easy to see. Remind students to point the slit at the light source (the light off papers) and then move their head slightly to sight the spectrum.

(2) It will take time for students to document the location of absorption lines. Please budget for this. It is easy to end up rushing the students.

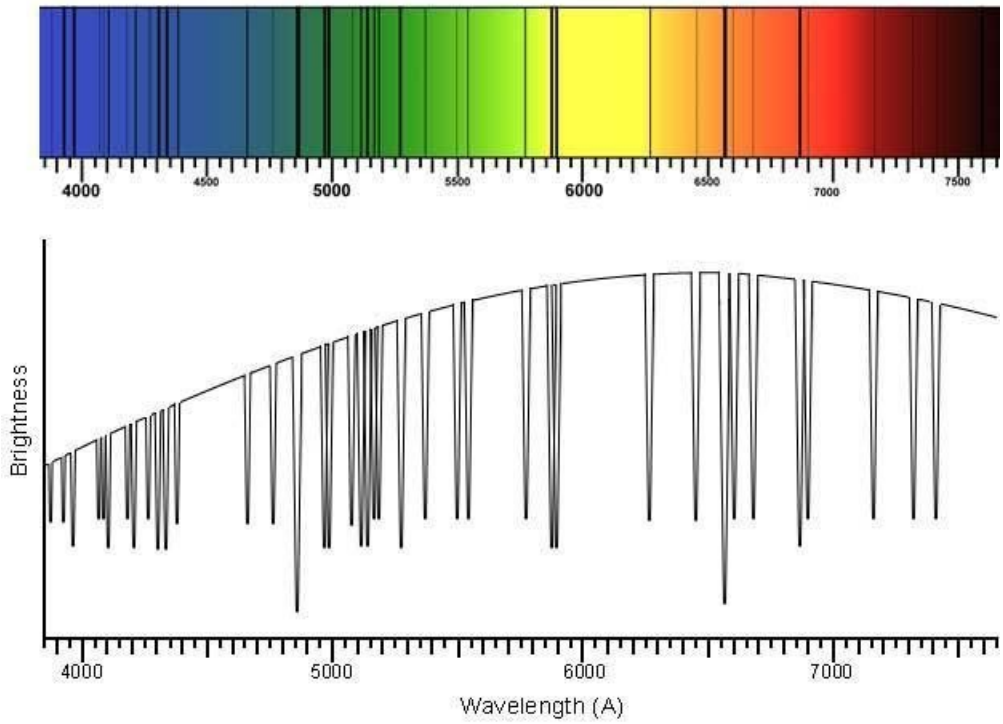
(3) Included with this lesson is a **Representative Data for Teacher Reference** you can use to train yourself (and maybe your students if they are really struggling). It describes a technique for blocking part of the incoming light to generate a clearer spectrum.

Pass out Part B of Explore (pages 4-5) in the Student Activity Handout.

Move to **slide 8** to introduce students to the figures used in part B. The spectrum is the sun's just like the spectra they observed in Part A, but shows pronounced absorption lines that students may have struggled to find in Part A. The graph below the spectrum shows the brightness of each color in the sun's spectrum. Dips represent black/missing colors created by absorption.

Display **slide 9** and share the goal of part B, which is to show that absorption lines in the sun spectrum match absorption produced by specific elements.

Have students look at the element absorption lines either by using an online database or by distributing the attached **Absorption Lines for Eight Elements Data** handout. Eight elements are included in the simplified database. Ask students to look for and mark specific element absorption lines on the solar spectrum (see sample data below). Reassure students that some elements do not match the solar spectrum very well and that it is okay if they don't find a match. You might want to work the first element together as a class demonstration to get everyone oriented. Students can do this matching without understanding why element absorption is happening in the stars. Those details will be made clearer during the Explain and Extend phases.



Once oriented, this part of Explore can go quite quickly. Be prepared to have students use extra class time to work on the Explain questions individually or in groups. Explain questions can also be assigned as homework.

Explain

Display **slides 11-12** to describe the Bohr diagrams which show energetic and physical changes for electrons in an atom.

Use **slide 13** to introduce or reinforce the logic that to absorb light in a star, the element must be in that star.

Assign students the Explain questions in the Student Activity Handout. Decide if you want them to work individually or in small groups. Encourage students to take chances and hypothesize their own ideas first. Then, facilitate some whole-class discussion as a follow up.

Teacher's Note: Explain Time Management

You could break up the work into two sections because Part A questions can be completed after Part A of the exploration and Part B questions can be completed after part B of the exploration. Questions can also be pared down to target the needs of your classroom. For example, Questions A1–A6 are closer to the lab experience and easier to answer without teacher discussion. Questions A7–A9 promote an (optional) discussion of what is happening inside of atoms during light absorption.

Part B Explain questions require Part B of Explore to be completed.

Extend

Teacher's Note: Selecting Extend Questions

The Extend section includes core follow up (questions 1–6) and optional enrichment (questions 7–10). Depending on your class, you might ask all students to work questions 1–6 and then direct students to relevant options in questions 7–10.

With Extend questions 1–6, students compare the spectra of two stars to infer general patterns about star spectra. First, ask students to attempt the core expansion of questions 1–6 on their own or with partners (at school or at home). Then, use **slide 14** to support follow up class discussion.

Extend questions 7–10 are optional. They can be cut to shorten the lesson or expanded and tailored to extend it for the entire class or a cohort of students. Consider using the "Gallery Walk" strategy to share out student results and evaluate (**slide 15**).

Evaluate

Slides 15-18 help introduce three options for evaluation.

Two-minute Paper (**slide 16**) is a strategy we recommend for a culminating summative activity. The suggested prompt on slide 16 should be tailored to address any specific point you want to emphasize.

Alternative Evaluation Options

During the Explore phase, Muddiest Point (**slide 17**) could be used following any discussion in the lesson to identify student confusions. A Gallery Walk (**slide 15**) could be used to organize student share out of Expand or Explain work. This tool could be used during or as a summative activity at the end of the lesson.

Resources

- Australian Academy of Science. (n.d.). Will looking at the sun really make you blind? Australian Academy of Science. https://www.science.org.au/curious/people-medicine/will-looking-sun-really-make-you-blind
- Anderson, Paul Scott. (2020, January 23). Goldilocks stars best for alien life? Earth Sky. https://earthsky.org/space/goldilocks-stars-g-k-dwarfs-best-for-alien-life
- K20 Center. (n.d.). Elbow partners. Strategies. https://learn.k20center.ou.edu/strategy/116
- K20 Center. (n.d.). Gallery Walk. Strategies. https://learn.k20center.ou.edu/strategy/118
- K20 Center. (n.d.). Muddiest Point. Strategies. https://learn.k20center.ou.edu/strategy/109
- K20 Center. (n.d.). Two-Minute Paper. Strategies. https://learn.k20center.ou.edu/strategy/152