National Aeronautics and Space Administration

NASA Helio Club

Session 5

Aurora: The Beauty of Space Weather

NASA Heliophysics Education Activation Team

Session 5: Aurora: The Beauty of Space Weather

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Time

120 minutes for the full progression of activities
-or- three **25 minute** activities that stand alone

Learning Goal

To expand learners' knowledge of the Sun's influence on Earth's systems.

Full Session Overview

Session 4 provided learners with background information on space weather and how it relates to interacting magnetic fields between the Sun and Earth. Session 5 will further explore these magnetic interactions by investigating how space weather can create a phenomenon at Earth's poles, known as the aurora. This session can stand on its own, but the background in session 4 is helpful when exploring the science of aurora. This session starts with a Know, Wonder, Learn (KWL) strategy for finding out what learners already know about aurora. Learners engage by looking at NASA's aurora image gallery and then viewing a video on the basics of aurora. Learners are also introduced to the properties of Earth's atmosphere and examine a graphic of how solar wind affects different objects in the solar system. In Activity 1 learners explore more about light and the electromagnetic spectrum by building their own spectroscopes. In Activity 2 learners apply their knowledge of space weather to predict the likelihood and locations of auroras. In activity 3 learners reinforce their knowledge by creating different types of aurora art, including a pony bead bracelet/keychain to remember the elements in the atmosphere that create aurora and chalk drawings. Learners will expand their knowledge by distinguishing between auroras and airglow. Use the KWL to assess knowledge gains.

- **Prior Knowledge:** What do you already know about aurora? KWL (15 minutes)
- **Engage:** What Is the Aurora? (15 minutes)
- **Explore: Activity 1:** Learning from Light (25 minutes)
- **Explain**: **Activity 2:** Predicting Aurora (25 minutes)
- **Extend: Activity 3:** Aurora Art (25 minutes)
- **Evaluate:** KWL (15 minutes)

Materials

NASA Helio Club Youth Guide (optional) includes all handouts for all six sessions. Quantities are per learner.

Basics

- ☐ Writing tools (pens or pencils)
- ☐ Art supplies (markers or crayons)
- ☐ (1) pair of scissors
- ☐ (1) roll of tape

Prior Knowledge/Evaluate

- ☐ (1) Handout_KWL_Session 5

Engage

- ☐ (1) Handout_What's in the Atmosphere
- ☐ (1) Handout_Aurora Colors
- ☐ (1) Handout_Solar Wind Across the Solar System

Explore: Activity 1

- ☐ (1) Paper towel tube, or use the Handout_Spectroscope Template, printed black/white on cardstock
- ☐ (1) Handout_Spectroscope Diagram
- ☐ (1) Handout_Electromagnetic Spectrum
- ☐ (1) Diffraction grating
- ☐ Aluminum foil (1 sheet, ~10" x 10")
- ☐ Scissors
- ☐ Tape

Explain: Activity 2

- ☐ (1) Handout_Aurora Kp Map of North America

Extend: Activity 3

- ☐ (1) Handout_Make an Aurora Bracelet
- ☐ (1) Handout_Aurora Chalk Art, print one-sided
- ☐ Pony beads:
  - ☐ (2) red
  - ☐ (2) purple
  - ☐ (4) green, 1, 1
- ☐ Letter beads:
  - ☐ (1) "O" letter bead
  - ☐ (1) "N" letter bead
- ☐ Sting (~1 yard)

- ☐ (1) Piece of black construction paper
- ☐ Chalk, green, red, purple
- ☐ Scissors
- ☐ Tape

Digital Resources

- Educator Resource: Educator Background Information
- Educator Resource: Slides_Session 5
- Video: Engage: NASA Space Place: What Is an Aurora?
- Webpage: Engage: International Space Station (ISS) Homepage
- Webpage: Activity 1: NASA's Aurora Webpage
- Webpage: Activity 1: NASA ICON Mission Homepage
- Webpage: Activity 2: NOAA 30-minute Aurora Forecast
- Video: Activity 3: Meet ICON: NASA's Airglow Explorer

Learning Objectives: At the end of the session, learners will be able to…

1. Identify the different layers of the atmosphere.
2. Describe the influence of a solar storm on Earth's magnetic field.
3. Predict the occurrence of auroras at different locations on Earth.
4. Analyze light using a homemade spectroscope.

Key Vocabulary

- **Airglow –** Diffuse bands of light that stretch 50 to 400 miles into our atmosphere, caused by molecules (mostly nitrogen and oxygen) becoming energized by ultraviolet (UV) radiation from sunlight.
- **Atmosphere –** The layer of gases surrounding a planet.
- **Aurora –** (Aurora borealis and aurora australis) often called the northern lights and southern lights, are light displays, more commonly seen at high latitudes, provoked by energy from the Sun and fueled by electrically charged particles trapped in Earth's magnetic field.
- **Coronal Mass Ejection (CME) –** Large clouds of solar plasma and embedded magnetic fields released into space after a solar eruption.
- **Electromagnetic (EM) Spectrum –** Comprised of all frequencies of electromagnetic radiation that propagate energy and travel through space in the form of waves.
- **Geomagnetic Storm –** A major disturbance of Earth's magnetosphere that occurs when variations in the solar wind produce major changes in the currents, plasmas, and fields in Earth's magnetosphere.
- **Infrared Light –** A form of electromagnetic radiation invisible to the human eye with wavelengths longer than visible light.
- **Ionosphere –** The ionized portion of Earth's atmosphere that occurs at the boundary of the atmosphere and space.
- **Ionization –** The process in which an electron is given enough energy to break away from an atom.
- **Kp-Index –** A 9-point scale that tells scientists how disturbed Earth's magnetic field is, based on an average of magnetic observations from around the world, measured every 3 hours.
- **Light Pollution –** A constant nighttime presence of light, emanating from artificial sources and obscuring views of the shared night sky.
- **Magnetic Field –** The area around a magnet that can exert a magnetic force.
- **Magnetosphere –** A region around a planet where the planet's internal magnetic field dominates over external magnetic fields such as that from the Sun.
- **Solar Flare –** Energetic bursts of light and particles triggered by the release of magnetic energy on the Sun.
- **Solar Wind –** A gusty stream of charged particles (mostly Hydrogen and a little Helium) that flows from the Sun in all directions, all the time, carrying the Sun's magnetic field out into space.
- **Space Weather –** Describes the impact of the solar wind on Earth's systems and technologies in orbit and on Earth.
- **Spectroscope –** A tool that separates light into its component colors (or wavelengths) to reveal information about the chemical content, temperature and motion of planets, comets, stars, interstellar gas, and galaxies.

- **Ultraviolet (UV) Light –** A form of electromagnetic radiation invisible to the human eye with wavelengths shorter than visible light.

Review the Educator Background Information **for more information on major concepts.**

Next Generation Science Standards (NGSS) Connections

MS-ESS1-1. Space Systems: Develop and use a model of the Earth-Sun-Moon system to describe the cyclic patterns of lunar phases, eclipses of the Sun and Moon, and seasons. In this session, learners explore the solar cycle and identify patterns of space weather.

MS-PS2-5. Forces and Interactions: Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. In this session, learners explore the magnetic fields of Earth and the Sun and how they interact.

MS-PS4-3. Waves and Electromagnetic Radiation: Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals. In this session, learners explore how space weather affects technology.

MS-PS4-2. Waves and Electromagnetic Radiation: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. In this session, learners explore the electromagnetic spectrum and how the atmosphere interacts with solar radiation.

MS-ETS1-4. Engineering Design: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. In this session, learners construct a spectroscope.

Targeted STEM Skills

Asking questions
In this session, learners ask questions using a KWL.

Developing and using models [MS-PS1-4] [MS-PS4-2] [MS-ESS1-1] [MS-ETS1-4]
In this session, learners create a model of a spectroscope.

Recognizing patterns [MS-ESS1-1]
In this session, learners identify patterns in auroral displays.

Steps: Full Session

**Italics indicate recommended scripts to use with students.*

Use the accompanying slides to help keep learners engaged.

- ➢ **Prior Knowledge:** What do you already know about aurora? KWL (15 minutes)
- ➢ **Engage:** What Is the Aurora? (15 minutes)
- ➢ **Explore: Activity 1:** Learning from Light (25 minutes)
- ➢ **Explain**: **Activity 2:** Predicting Aurora (25 minutes)
- ➢ **Extend: Activity 3:** Aurora Art (25 minutes)
- ➢ **Evaluate:** KWL (15 minutes)

Prior Knowledge: What do you already know about aurora?

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Overview
(15 Minutes)

A KWL chart is an effective way to assess learners' prior knowledge, identify misconceptions, and measure growth. Use the guiding questions provided in the chart below to focus learners on the content that is explored in this session.

As students share their ideas and predictions, don't give them the answers just yet; rather, encourage them to investigate their questions throughout the session.

If you don't use the Youth Guide, have learners use a notebook to record their observations, draw diagrams, and collect data.

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Materials

- Handout_KWL_Session 5

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Instructions

A. **Direct learners to page 60** in the NASA Helio Club Youth Guide, or print the Handout_KWL_Session 5

B. Have learners complete the **K [Know Column]** and the **W [Wonder Column]** of the KWL chart. Instruct them to leave the L [Learn Column] blank until the end of the session. [Slide 4]

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KWL

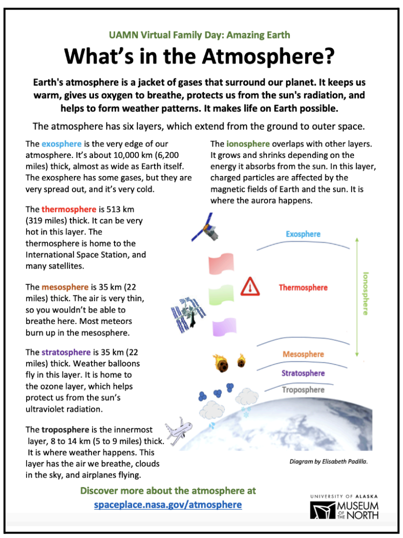
[K] – What do you already know?	[W] – What do you wonder about?	[L] – What did you learn?
What do you already know about the Aurora Borealis, also known as the Northern Lights? • *What is it?* • *What causes it?* • *Where does it occur?*	*Record questions you have about aurora in this column.*	*Record what you learned about aurora in this column.*

Engage: What is the Aurora?

Overview
(15 Minutes)

This activity introduces learners to **aurora** by having them examine NASA's Aurora Image Gallery, followed by an explanatory short video from NASA Space Place.

Learners then examine the properties of Earth's **atmosphere**, which is made of mostly oxygen and nitrogen. When these gases are **ionized** by the **solar wind**, they glow.


UAMN Virtual Family Day: Amazing Earth

What's in the Atmosphere?

Earth's atmosphere is a jacket of gases that surround our planet. It keeps us warm, gives us oxygen to breathe, protects us from the sun's radiation, and helps to form weather patterns. It makes life on Earth possible.

The atmosphere has six layers, which extend from the ground to outer space.

The exosphere is the very edge of our atmosphere. It's about 10,000 km (6,200 miles) thick, almost as wide as Earth itself. The exosphere has some gases, but they are very spread out, and it's very cold.

The ionosphere overlaps with other layers. It grows and shrinks depending on the energy it absorbs from the sun. In this layer, charged particles are affected by the magnetic fields of Earth and the sun. It is where the aurora happens.

The thermosphere is 513 km (319 miles) thick. It can be very hot in this layer. The thermosphere is home to the International Space Station, and many satellites.

The mesosphere is 35 km (22 miles) thick. The air is very thin, so you wouldn't be able to breathe here. Most meteors burn up in the mesosphere.

The stratosphere is 35 km (22 miles) thick. Weather balloons fly in this layer. It is home to the ozone layer, which helps protect us from the sun's ultraviolet radiation.

The **troposphere** is the innermost layer, 8 to 14 km (5 to 9 miles) thick. It is where weather happens. This layer has the air we breathe, clouds in the sky, and airplanes flying.

Diagram by Elisabeth Padilla.

Discover more about the atmosphere at spaceplace.nasa.gov/atmosphere

University of Alaska Museum of the North

Handout_What's in Earth's Atmosphere?
Credit: UAF

While **ionization** is a challenging concept, it is important for learners to

Materials

- (1) Handout_What's in the Atmosphere
- (1) Handout_Aurora Colors
- (1) Handout_Solar Wind Across the Solar System

Instructions

A. **Observe:** Direct learners to examine images from NASA's Aurora Webpage and ask them to record their observations, using the guiding questions: [Slide 5]

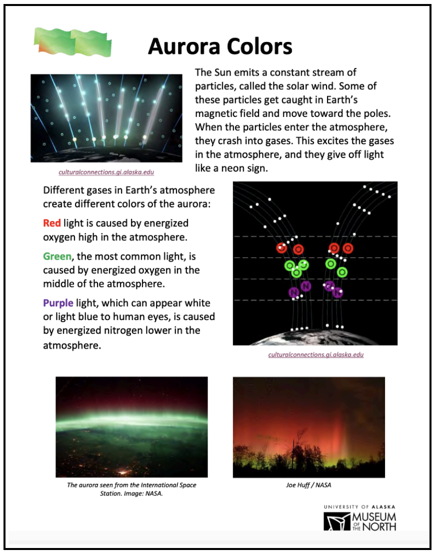
- What colors do you observe in the light displays?
- What shapes do you observe in the light displays?
- At what time of day are the images taken?
- From what perspectives are the images taken from?

B. **Watch:** NASA Space Place: What Is an Aurora? Direct students to consider the following questions as they watch the short video. [Slide 6]

- What is the **solar wind**?
- What causes the **solar wind** to enter into Earth's **atmosphere**?
- What happens when the **solar wind** bumps into particles in Earth's **atmosphere**?
- Do other planets experience **aurora**? Which ones?

C. **Provide Context:** ***Aurora*** *displays occur when the* ***solar wind*** *interacts with Earth's* ***atmosphere.*** *The* ***aurora*** *is seen most often at the North and South Pole, and at high latitudes, because of the shape of Earth's* ***magnetic field****, which originates from Earth's poles.*

understand that when atoms get excited, they release energy, in this case, light.


Aurora Colors

The Sun emits a constant stream of particles, called the solar wind. Some of these particles get caught in Earth's magnetic field and move toward the poles. When the particles enter the atmosphere, they crash into gases. This excites the gases in the atmosphere, and they give off light like a neon sign.

culturalconnections.gi.alaska.edu

Different gases in Earth's atmosphere create different colors of the aurora:

Red light is caused by energized oxygen high in the atmosphere.

Green, the most common light, is caused by energized oxygen in the middle of the atmosphere.

Purple light, which can appear white or light blue to human eyes, is caused by energized nitrogen lower in the atmosphere.

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The aurora seen from the International Space Station. Image: NASA.

Joe Huff / NASA

UNIVERSITY OF ALASKA MUSEUM OF THE NORTH

Handout_Aurora Colors
Credit: UAF

Learners also examine a NASA graphic that shows how different objects in the solar system interact with the **solar wind.** Objects, like Earth and Jupiter, which have both an **atmosphere** and a **magnetosphere,** experience **aurora**. Objects without a **magnetosphere** have their **atmospheres** blown away by the **solar wind**, like Mars.

Direct learners to page 61 of the NASA Helio-Club Youth Guide or to the Handout_What's in the Atmosphere? [Slide 7]

*Earth's **atmosphere** is a "jacket" of gases that surrounds our planet. It keeps us warm, gives us oxygen to breathe, protects us from the Sun's radiation, and helps to form weather patterns. It makes life on Earth possible.*

*The **atmosphere** has six layers, which extend from the ground to outer space. These layers are determined by temperature.*

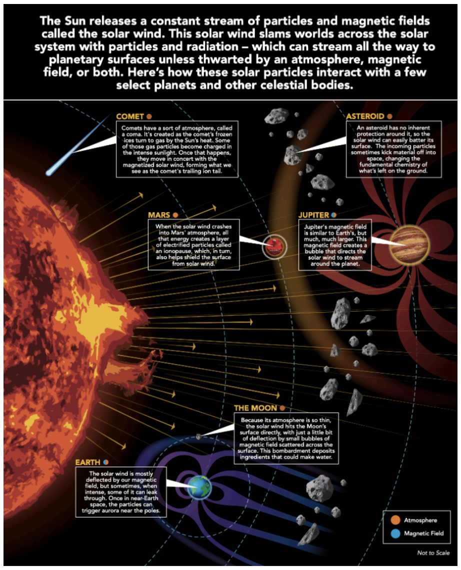
*Notice that the **ionosphere** overlaps with other layers. The **ionosphere** is part of Earth's upper **atmosphere**, between 80 and about 600 km above the surface of Earth. This is where Earth weather meets **space weather** and where the **aurora** occurs. The **ionosphere** is home to satellites and astronauts on the International Space Station (ISS).* [Slide 8]

*It is called the **ionosphere** because when the Sun's energy heats up the gases that make up the atmosphere, the atoms and molecules become **ionized**, which means they lose an electron or two, creating a sea of electrically charged particles.*

***Ionization** is the process in which an electron is given enough energy to break away from an atom. **Ionization** takes a lot of energy. The process of ionization forms **plasma.** Remember that the Sun and the **solar wind** are made of **plasma**.* [Slide 9]

Direct learners to page 62 of the NASA Helio Club Youth Guide or to the Handout_Aurora Colors. [Slide 10]

*When the gasses in Earth's **atmosphere** get excited, they emit light. Different gases in the **atmosphere** create different colors of **aurora**. Red light is caused by*



Handout_Solar Wind Across the Solar System

Credit: NASA

energized oxygen, high in the ***ionosphere****. Green, the most common light, is caused by energized oxygen in the middle of the* ***ionosphere****. Purple light, which can appear white or light blue, is caused by energized nitrogen in the lower part of the* ***ionosphere****.*

D. **Examine: Direct learners to page 63** of the NASA Helio Club Youth Guide or to the Handout_Solar Wind Across the Solar System infographic. [Slide 11]

Auroral displays show the ***atmosphere*** *and the* ***magnetosphere*** *working in tandem to protect Earth from harmful radiation and particles coming from the Sun.*

Have learners consider:

- *Other than Earth, which object on this infographic would also likely have an* ***aurora****? What is your evidence?*
- *What evidence is there that the* ***solar wind*** *can change the surface of an object?*
- *How is a comet similar to an* ***aurora****?*

Give learners time to examine the infographic and share their observations.

Major Concepts

★ **Aurora** is caused by the Sun!

★ The **solar wind** is composed of charged particles that constantly flow out from the Sun in all directions. The **solar wind** can intensify during **solar storms**, like **Coronal Mass Ejections (CMEs)** and **solar flares**.

★ **Aurora** displays occur at Earth's poles because of the shape of Earth's **magnetic field**, which funnels the **solar wind** to the poles, where it interacts with Earth's **atmosphere**.

★ Earth's **atmosphere** is a "jacket" of gases that surrounds the planet.

★ The **ionosphere,** the upper most part of Earth's atmosphere, is where Earth weather meets **space weather** and where the **aurora** occurs.

★ It is called the **ionosphere** because when the Sun's energy heats up the gases in the **atmosphere** the atoms and molecules become **ionized**, which means they lose an electron or two, creating a sea of electrically charged particles.
★ Auroral displays show the **atmosphere** and the **magnetosphere** working in tandem to protect Earth from harmful radiation and particles coming from the Sun.
★ Other planets with both **magnetospheres** and **atmospheres** experience **aurora**.
★ Jupiter also experiences **auroras** because it has both an **atmosphere** and a **magnetosphere**.

Featured NASA Mission: Only 400 kilometers (250 miles) above our heads, the International Space Station (ISS) streaks across the sky at 36,000 kilometers (17,500 miles) per hour, orbiting Earth every 90 minutes. The station carries an impressive array of research facilities supporting hundreds of experiments at any given time across every major science discipline. Monitoring space weather is important for keeping the astronauts and equipment on the station safe.

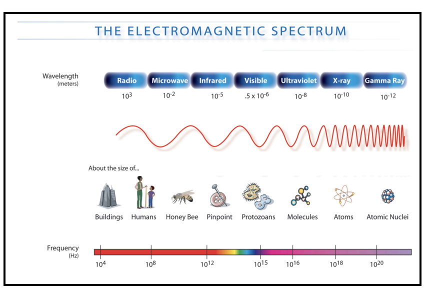
Explore: Learning from Light

Overview of Activity 1 (25 Minutes)

In this activity, learners will continue their exploration of light by building their own **spectroscope**, a tool that astronomers use to analyze light.

In the engage activity, learners discovered that excited oxygen atoms glow green and red, and that nitrogen atoms glow purple. Just like the color of the aurora tells us about the composition of the **atmosphere**, the analysis of light coming from distant objects can tell us about the composition of that object.

Learners will make a simple **spectroscope** that analyzes visible light. There are spectroscopes that analyze all different kinds of light.



EM Spectrum
Credit: NASA/Afterschool Universe

Materials

- (1) Paper towel tube, or use the Handout_Spectroscope Template, printed black/white on cardstock
- (1) Handout_Spectroscope Diagram
- (1) Handout_Electromagnetic Spectrum
- (1) Diffraction grating
- Aluminum foil (1 sheet, ~10" x 10")
- Scissors
- Tape

Instructions

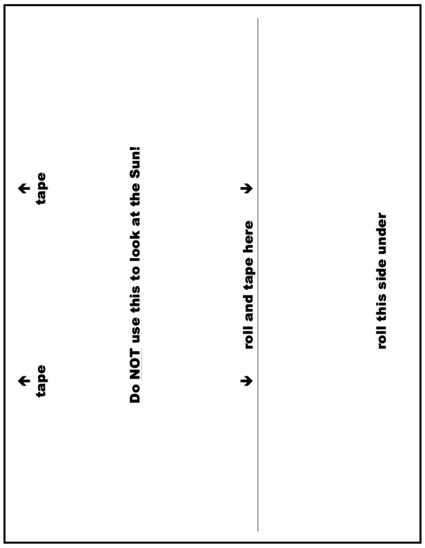
A. **Provide Context: Direct learners to page 25** of the NASA Helio Club Youth Guide to reexamine the diagram of the EM Spectrum, or use the Handout_Electromagnetic Spectrum. [Slide 12]

*So why do excited oxygen molecules produce green and red **auroras**? Why do nitrogen molecules create purple **auroras**?*

Different gases, when excited, create different wavelengths of light, displaying different colors. That is why we call neon signs 'neon,' because they are made of excited neon gas, which glows bright orange. Neon signs come in different colors because they use other gases, too; mercury glows blue, for example.

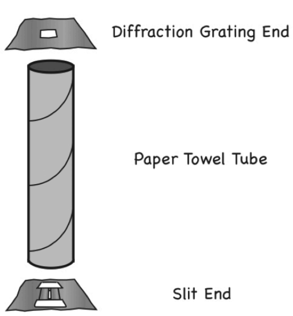
Most of what scientists know about the universe comes from studying light. We can even use light to learn information about far-away objects, including the chemical make-up, temperature, motion, size, and age of the object.

*We are familiar with telescopes, which capture light. There are many different types of telescopes that capture different types of light on the **EM spectrum**.*



Spectroscope Template
Use in place of a paper towel tube.
Credit: NASA/Afterschool Universe

Take learners through the construction of the spectroscope step by step.



Spectroscope Diagram
Credit: NASA/Afterschool Universe

Learners can view the **aurora** with the spectroscope, if given the opportunity, but unless you live near Earth's poles, you may not get the opportunity very

Another tool that astronomers use, as well as lots of other scientists, is a ***spectroscope,*** *which is a tool that separates light by different wavelengths, which helps scientists to learn more about the object they are studying. The* ***spectroscope*** *works similarly to a prism, which separates visible light into all the different wavelengths of color.* [Slide 13]

You could say that telescopes collect the light and that ***spectroscopes*** *analyze the light.*

NASA's ICON Mission (Ionospheric Connection Explorer) uses ***spectroscopes*** *to study the* ***ionosphere*** *by capturing images of oxygen glowing in the upper atmosphere. This helps track the response of the space environment to weather in the lower* ***atmosphere****.* [Slide 14]

B. **Build:** If you don't have a paper towel tube, you can use the Handout_Spectroscope Template, printed black/white on cardstock, also on **page 65** of the NASA Helio Club Youth Guide. [Slide 15]

Take learners step-by-step through the procedure to build their own **spectroscope**; see procedure below. [Slide 16-17]

Direct learners to page 67 of the NASA Helio Club Youth Guide to see the last steps of how to construct the pieces of the spectroscope, or use the Handout_Spectroscope Diagram. [Slide 18]

Make sure learners align the spectroscope before taping down the slit end. Essentially the slit needs to be aligned with the grooves on the diffraction grating. See procedure below. [Slide 19]

C. **Experiment:** *To use the spectroscope, look through the diffraction-grating end and point the slit at the light source.* [Slide 20]

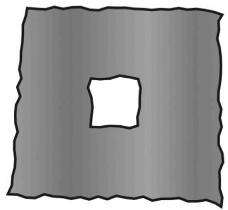
often. But learners can compare different light sources around us in everyday life: Compact fluorescent light (CFL) bulbs and black CFL bulbs are interesting to look at; if learners can find neon lights around town, those are fun to look at, too.	*Use your* ***spectroscope*** *to analyze different lights around your house. Many bulbs now are light-emitting diodes (LED), which don't produce a very interesting spectrum, but if you have old fluorescent bulbs in your house, they show a more complete spectrum.* [Slide 20] ***NEVER LOOK AT THE SUN WITH YOUR SPECTROSCOPE!*** *To safely observe the spectrum of sunlight, you can turn your back to the Sun and point your spectroscope at the blue sky.* *If you are lucky enough to live in a place with an* ***aurora****, you can experiment using your* ***spectroscope*** *to view the light from auroral displays.* Give learners time to experiment. Have learners share their observations.

Spectroscope Build Procedure

(1) If you don't have a cardstock Handout_Spectroscope Template, tear out **page 65** of the NASA Helio Club Youth Guide and roll it into a tube following the directions on the template. Tape to secure.

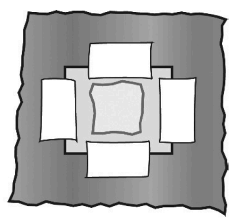
(2) Cut two pieces of aluminum foil into a square approximately 4" x 4" and two smaller strips of foil approximately 1" x 3."

(3) Cut a small hole in the center of both pieces of 4" x 4" foil — a hole that is smaller than the square piece of diffraction grating.



A foil square with a hole in the center.

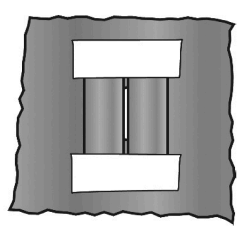
(4) Take one piece of 4" x 4" aluminum foil and tape the diffraction grating over the hole.



Diffraction grating taped over the hole in the foil square.

(5) Fold two of the smaller strips of foil in half lengthwise.

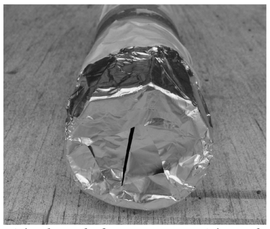
(6) Take the second piece of 4" x 4" aluminum foil and tape the folded foil strips on each side of the hole, creating a slit about the width of the edge of a coin.



Construction of the slit end of the spectroscope.

Use the Handout_Spectroscope Diagram on **page 67** in your NASA Helio-Club Youth Guide to construct your spectroscope.

(7) Fold down the aluminum foil around one end of the tube and tape down the diffraction grating end, but don't tape the slit end down yet.



The slit end of a spectroscope. This end points at your light source.

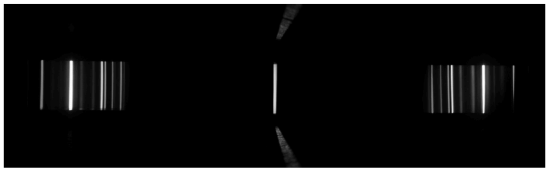
The diffraction grating end of a spectroscope. This end goes up to your eye

(8) We need to align the **spectroscope** before taping down the slit end.

Aligning the Spectroscope: Hold the **spectroscope** so that you can look through the diffraction grating end (the plastic square should be about as close to your eye as your glasses' lens or as close as you would put a microscope).

Place the slit end on, but don't tape it down. Point the slit end of the **spectroscope** towards a light source – this can be any light in the room, but NEVER look at the SUN!

Look for a rainbow in the **spectroscope**, a little bit off to the side or up or down (you should be able to see regular light from your source coming through the slit, but the rainbow will be off-center).



These nice orderly lines represent a fully aligned spectroscope. If this is what you are seeing through yours, you can tape the slit end in place.

Twist the slit end until you can see a rainbow with nice orderly parallel lines, like in the diagram above. Your spectroscope is aligned and you can tape down the slit end.

Activity 1 Major Concepts

- ★ A tool that astronomers use, as well as lots of other scientists, is a **spectroscope,** which separates light into its different wavelengths.
- ★ Different elements create different wavelengths of light, displaying different colors.
- ★ Most of what scientists know about the universe comes from studying light. They use light to learn information about far-away objects, including the chemical make-up, temperature, motion, size, and age of the object.
- ★ Do not use the **spectroscope** to look at the Sun.

Featured NASA Mission: NASA's Ionospheric Connection Explorer (ICON) Mission studies the frontier of space: the dynamic zone high in our atmosphere where Earth weather and space weather meet. This mission helps determine the physics of our space environment and pave the way for mitigating its effects on our technology, communications systems, and society.

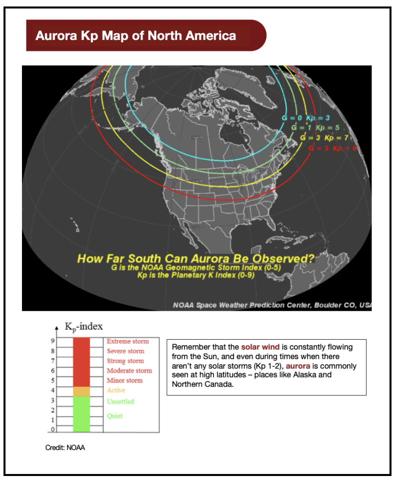
This activity was adapted from the NASA Afterschool Universe curriculum: Session 5: Astronomer's Toolbox: Spectroscopes. *All images above are credited to the NASA GSFC Astrophysics Education Team.*

Explain: Predicting Aurora

Overview of Activity 2 (25 Minutes)

In this activity, learners predict the likelihood of **aurora** on Earth by examining the **Kp-index** and using NOAA's 30-minute aurora forecast.

Emphasize to learners that what we observe about **auroras** can tell us about the activity on the Sun and help scientists monitor and predict **space weather**.



Aurora KP Map of North America
Credit: NOAA

Materials

- (1) Handout_Aurora Kp Map of North America

Instructions

A. **Provide Context:** ***Auroras*** *are not always indicative of severe* ***space weather****, and can occur regularly at the poles, even with very little disturbance to Earth's magnetic field. But during solar eruptions, like* ***coronal mass ejections (CMEs)****, the disturbance in the magnetic field would cause the aurora to intensify and to be seen at lower latitudes.*

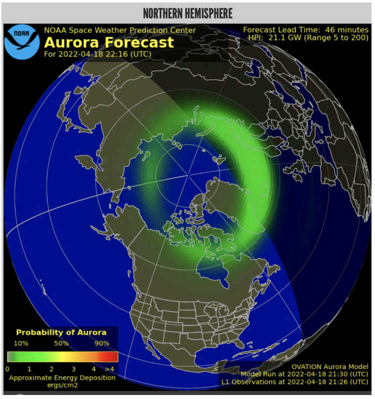
B. **Analyzing Data: Direct learners to page 68** of the NASA Helio Club Youth Guide, or use the Handout_Aurora Kp Map of North America.

   This map shows the **Kp-index** levels that are required to view **auroras** at different latitudes. [Slide 21]

   When ***geomagnetic*** *activity is low (Kp-3), the* ***aurora*** *typically can be seen in the hours around midnight, at about 67 degrees magnetic latitude (Alaska in the Northern Hemisphere). As activity increases, the region of* ***aurora*** *expands toward the equator.*

   When ***geomagnetic*** *activity is very high, caused by a* ***CME****, for example, the* ***aurora*** *may be seen at mid- and low-latitude locations around Earth that would otherwise rarely experience the phenomenon. Most of the continental U.S. is at mid-latitudes.*

   A ***geomagnetic storm*** *with a Kp-9 can be seen in Washington, DC, with the right kind of conditions.*



NOAA Aurora Forecast
Credit: NOAA

*Other conditions that affect viewing the **aurora** include cloud cover, light interference from the full or near-full Moon, and **light pollution** from nearby cities.*

Direct learners to NOAA's Space Weather Prediction Center 30-minute Aurora Forecast, which offers real-time data on current **aurora** conditions. [Slide 22]

Instruct learners to watch the forecast and use these guiding questions in their analysis of the data:

- *What is the probability of seeing an **aurora** at high latitudes (near the pole) right now?*
- *Is there any chance of seeing an **aurora** near where you live?*
- *What does this data tell you about the current activity on the Sun?*

Give learners time to examine the forecast. Have learners share their observations.

Activity 2 Major Concepts

★ **Auroras** are not always indicative of severe **space weather**, and can occur regularly at the poles, even with very little disturbance to the Earth's magnetic field.

★ During solar eruptions, like **coronal mass ejections (CMEs)**, the disturbance in the magnetic field would cause the **aurora** to intensify and to be seen at lower latitudes.

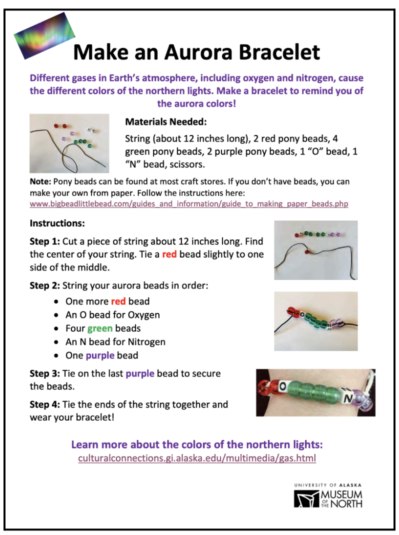
★ Other conditions that affect viewing the **aurora** include cloud cover, light interference from the full or near-full Moon, and **light pollution** from nearby cities.

Extend: Aurora Art

Overview of Activity 3 (25 Minutes)

In this extension activity, students use art to demonstrate their knowledge of aurora.

The aurora bracelet, or keychain, uses red, green, and purple pony beads, arranged with an "O" bead for Oxygen and an "N" bead for Nitrogen to remind learners of the gasses in the atmosphere that get excited to create the colors of **aurora**.


Make an Aurora Bracelet

Different gases in Earth's atmosphere, including oxygen and nitrogen, cause the different colors of the northern lights. Make a bracelet to remind you of the aurora colors!

Materials Needed:

String (about 12 inches long), 2 red pony beads, 4 green pony beads, 2 purple pony beads, 1 "O" bead, 1 "N" bead, scissors.

Note: Pony beads can be found at most craft stores. If you don't have beads, you can make your own from paper. Follow the instructions here: www.bigbeadlittlebead.com/guides_and_information/guide_to_making_paper_beads.php

Instructions:

Step 1: Cut a piece of string about 12 inches long. Find the center of your string. Tie a **red** bead slightly to one side of the middle.

Step 2: String your aurora beads in order:

- One more **red** bead
- An O bead for Oxygen
- Four **green** beads
- An N bead for Nitrogen
- One **purple** bead

Step 3: Tie on the last **purple** bead to secure the beads.

Step 4: Tie the ends of the string together and wear your bracelet!

Learn more about the colors of the northern lights:
culturalconnections.gi.alaska.edu/multimedia/gas.html

UNIVERSITY OF ALASKA MUSEUM OF THE NORTH

Make an Aurora Bracelet Handout

Credit: UAF

Materials

- (1) Handout_Make an Aurora Bracelet
- (1) Handout_Aurora Chalk Art, print one-sided
- Pony beads:
  - (2) red
  - (2) purple
  - (4) green, 1, 1
- Letter beads:
  - (1) "O" letter bead
  - (1) "N" letter bead
- Sting (~1 yard)
- (1) Piece of black construction paper
- Chalk, green, red, purple
- Scissors
- Tape

Instructions

A. **Provide Context:** *When the **solar wind** interacts with gases in the **atmosphere, ionization** occurs, causing the gases in the **ionosphere** to glow.*

This is similar to how the neon lights that you see in store windows work. Electricity excites the different gases in the neon light tubes; different gases glow different colors.

*The Earth's **atmosphere** is made up of 78% nitrogen, 21% oxygen, and a small amount of argon, carbon dioxide, methane, and some other trace amounts of gases.*

When oxygen atoms and molecules collide, they emit the visible green and red light of the aurora. When nitrogen atoms and molecules collide, they emit the


Aurora Chalk Art

Create your own artwork inspired by the northern lights!

Materials Needed:

Aurora stencil (or draw your own), black paper, colored chalk, scissors. *Optional:* Tissues.

Instructions:

Step 1: Cut out the aurora stencil. If making your own, cut a strip of white paper or cardstock in a wavy aurora shape.

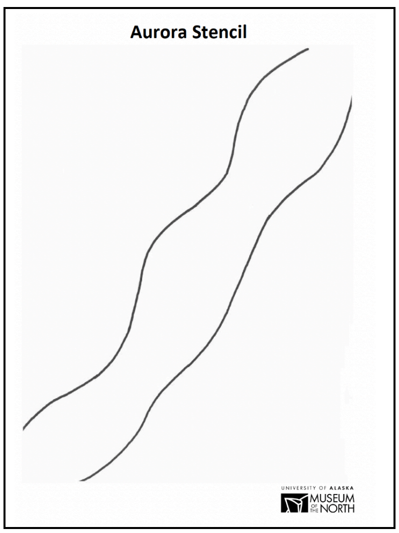
Step 2: Color the top edge of the stencil with colored chalk.

Step 3: Place the colored stencil on your black paper, chalk side up. Smudge the chalk onto the black paper using your finger or a tissue.

Step 4: Repeat using different colors to fill the sky with the colors of the aurora.

Step 5: Add a cabin, trees, campfires, or other things you might see under the northern lights. Be creative!

Activity adapted from Cultural Connections Project, UAF Geophysical Institute: culturalconnections.gi.alaska.edu



Aurora Chalk Art Handout

Credit: UAF

visible purple and blue light of the aurora.

B. **Create: Direct learners to page 69** of the NASA Helio Club Youth Guide, or use the Handout_Make an Aurora Bracelet. [Slide 24]

To remember what the colors mean, we can make an aurora bracelet. If you don't wear bracelets, you can attach it to a keychain or hang the beads in a window!

Remind learners to string the beads in the correct order, which will start with the upper **atmosphere** and move down toward the lower **atmosphere**.

*(1) String the **two red beads** onto the yarn first; red is caused by energized oxygen high in the atmosphere.*

*(2) Next, string the **"O" letter bead** for oxygen. The "O" will be between the red and green beads, both colors created by oxygen.*

*(3) Next, string the **four green beads**. Green is created by oxygen in the middle atmosphere, and we use four beads to remind us that it is the most common color seen in the aurora.*

*(4) Next, string the **"N" letter bead** for nitrogen.*

*(5) String the **two purple beads** last; purple is caused by energized nitrogen in the lower atmosphere.*

C. **Create: Direct learners to page 70** of the NASA Helio Club Youth Guide, or use the Handout_Aurora Chalk Art. [Slide 25]

Step 1: Cut out the aurora stencil (page 71). If making your own, cut a strip of white paper or cardstock in a wavy aurora shape.

Step 2: Color the top edge of the stencil with colored chalk.

Step 3: Place the colored stencil on your black paper, chalk side up. Smudge the chalk onto the black paper using your finger or a tissue.

Step 4: Repeat using different colors to fill the sky with the colors of the aurora.

Step 5: Add a cabin, trees, campfires, or other things you might see under the northern lights. Be creative!

D. **Provide Context:** *If you are out at night, hoping to catch a glimpse of the **aurora**, make sure not to confuse **aurora** with **airglow**.*

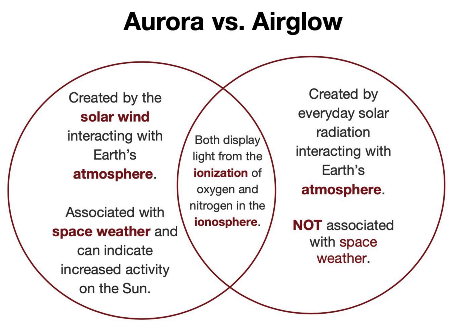
*We have learned that an **aurora** is created when the **solar wind**, a gusty stream of charged particles from the Sun, interacts with Earth's magnetic field.*

***Airglow**, which also occurs in the **ionosphere**, and produces similar light displays as an **aurora**, is caused by the everyday solar radiation we receive from the Sun. **Airglow** is not associated with increased solar activity, as **auroras** are.*

E. **Watch:** *Working together with other missions, data collected from NASA's ICON Mission contributes to scientists' understanding of the **atmosphere**, planetary weather, **space weather**, **aurora**, and the Sun.* [Slide 26]

Instruct learners to view this video: [Meet ICON: NASA's Airglow Explorer], to learn more about how NASA's ICON Mission studies the **ionosphere** and **airglow.**

Have learners make observations from the video about how **airglow** is different from **aurora**. Perhaps have them create a venn diagram, or other graphic organizer. [Slide 27]



Venn Diagram

Activity 3 Major Concepts

- ★ Both **aurora** and **airglow** occur in the **ionosphere.**
- ★ **Auroras** are created when the **solar wind**, a gusty stream of charged particles from the Sun, interacts with the Earth's magnetic field.
- ★ **Airglow** is caused by the everyday solar radiation we receive from the Sun.
- ★ **Airglow** is not associated with increased solar activity, as **auroras** are.
- ★ While **auroras** can be viewed from both Earth and space, **airglow** is usually only visible from space.

Featured NASA Mission: NASA's [Ionospheric Connection Explorer (ICON) Mission] studies the frontier of space: the dynamic zone high in our atmosphere where Earth weather and space weather meet. This mission helps determine the physics of our space environment and pave the way for mitigating its effects on our technology, communications systems, and society. ICON studies both **aurora** and **airglow.**

Evaluate: What did you learn about aurora?

Overview of Activity (15 Minutes)	Materials
At the end of the session, learners complete the KWL chart, adding what they learned to the L [Learn] column. Encourage learners to look through Session 5 in the NASA Helio Youth Guide, and to review the activities and the observations they recorded during the activities, to help them summarize what they learned during the session.	• Handout_KWL_Session 5 **Instructions** A. **Direct learners to page 60** in the NASA Helio Club Youth Guide, or print the Handout_KWL_Session 5 [Slide 27] B. Have learners complete the **L [Learn Column]** of the KWL chart. Emphasize to learners that they should also be correcting any misconceptions they had prior to the session, from the K [Know] column, and answering any questions from the W [Wonder] column, if they are able to.

Session 5 Major Concepts

- ★ **Aurora** displays occur when the **solar wind** interacts with the Earth's **atmosphere.**
- ★ The **aurora** is seen most often at the North Pole and South Pole, and at high latitudes, because Earth's **magnetic field** guides particles trapped in the field, into the poles.
- ★ The **ionosphere** is where Earth weather meets **space weather** and where **auroras** occur.
- ★ When the **solar wind** interacts with gases in the **atmosphere**, **ionization** occurs, causing the gases in the **ionosphere** to glow.
- ★ When oxygen atoms and molecules collide, they emit the visible green and red light of the **aurora**.
- ★ When nitrogen atoms and molecules collide, they emit the visible purple and blue light of the **aurora**.
- ★ Auroral displays show the **atmosphere** and the **magnetosphere** working in tandem to protect Earth from harmful radiation and particles coming from the Sun.
- ★ **Auroras** are not always indicative of severe **space weather**, and can occur regularly at the poles, even with very little disturbance to the Earth's magnetic field.
- ★ During solar eruptions, like **coronal mass ejections (CMEs)**, the disturbance in the magnetic field would cause the **aurora** to intensify and to be seen at lower latitudes.
- ★ Both **aurora** and **airglow** occur in the **ionosphere**. **Airglow** is caused by the everyday solar radiation we receive from the Sun, while **auroras** are created by the **solar wind**.

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