National Aeronautics and Space Administration

NASA Helio Club

Session 5

Aurora: The Beauty of Space Weather

NASA Heliophysics Education Activation Team

Materials Needed for This Session

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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

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Use a notebook or the extra paper in the Helio Club Youth Guide to record observations, collect data, and organize ideas.

Session 5: Notes

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What do you already know about space weather?

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Session 5: KWL		
K - what do we already know?	**W- what do we wonder about?**	**L- what did we learn?**
What do we already know about the Aurora Borealis, also known as the Northern Lights? What is it? What causes it?	**Record questions you have about the Aurora Borealis in this column.**	**Record what you learned about the Aurora Borealis in this column.**

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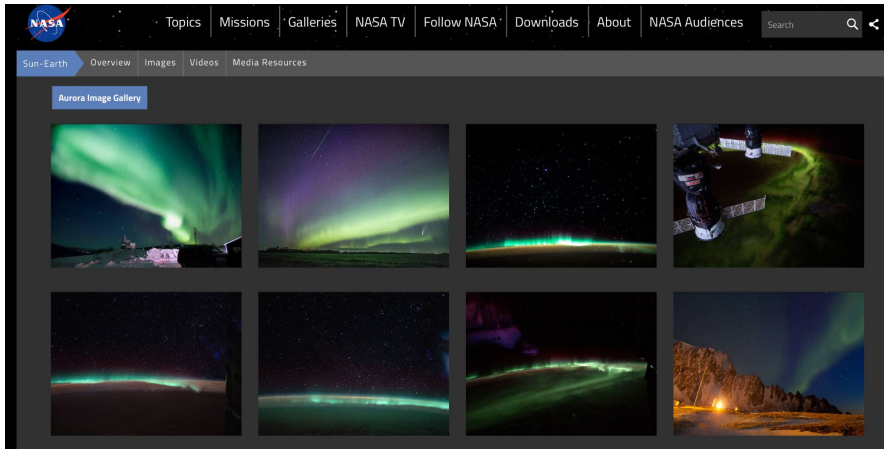
NASA Aurora Images



Examine the images from [NASA's Aurora webpage]

Consider:

- 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?

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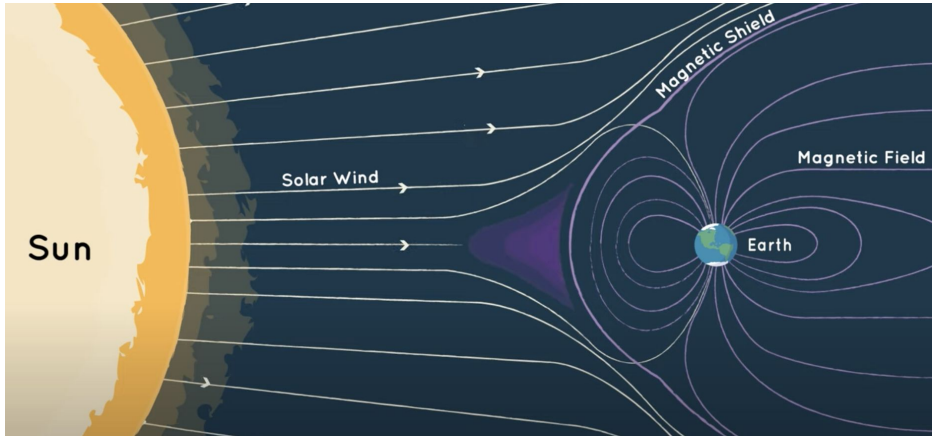
Video: What Is an Aurora?

NASA Space Place: What Is an Aurora?



Still image from video *Credit: NASA Space Place*

Still image from video *Credit: NASA Space Place*

Aurora occurs when the **solar wind** interacts with Earth's **magnetic field**.

Another important part of understanding the aurora is learning about the atmosphere.

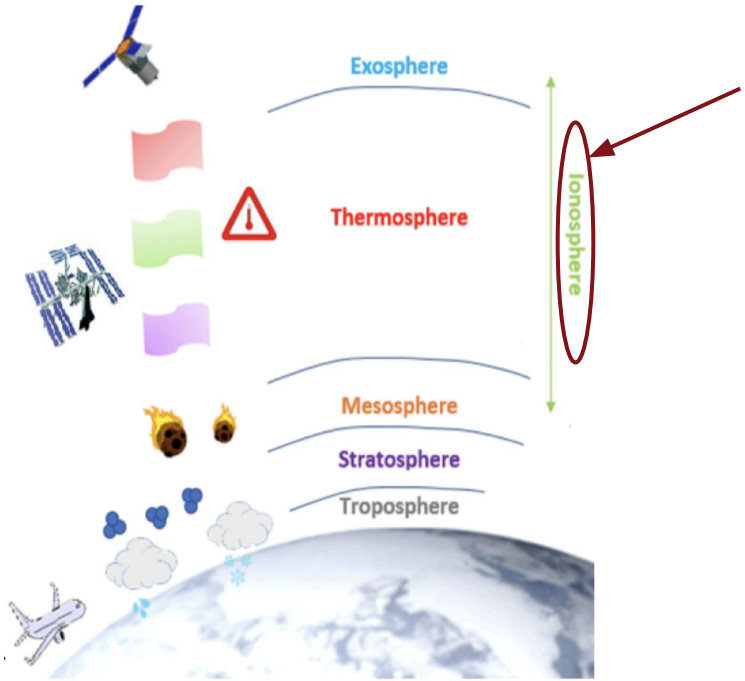


Diagram by Elisabeth Padilla.

Credit: University of Alaska Museum of the North

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.

Image Credit: Sebastian Saarloos

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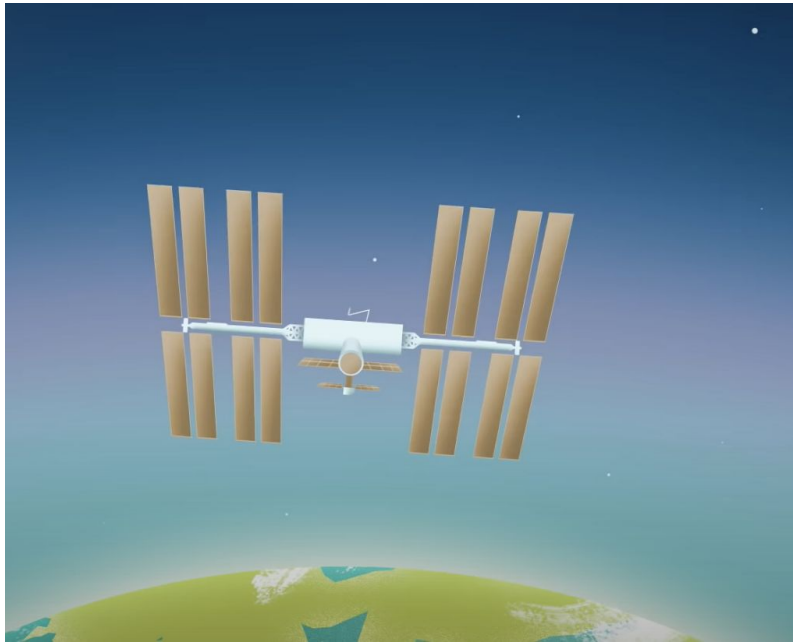
International Space Station

The **International Space Station (ISS)** is in the ionosphere!

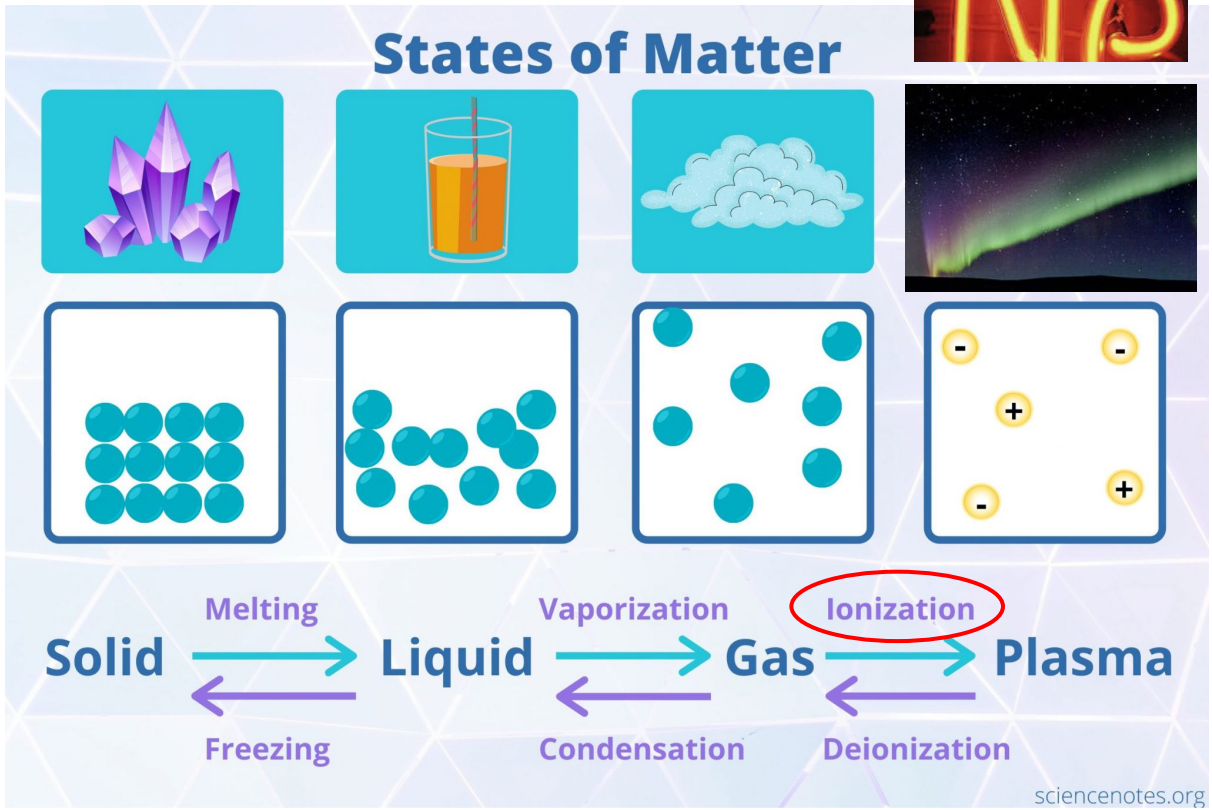


Animation of the ISS *Credit: NASA SVS / GSFC*

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.

What is ionization?

Neon signs are made of ionized gas!



Aurora Image Credit: NASA/Terry Zaperach

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**.

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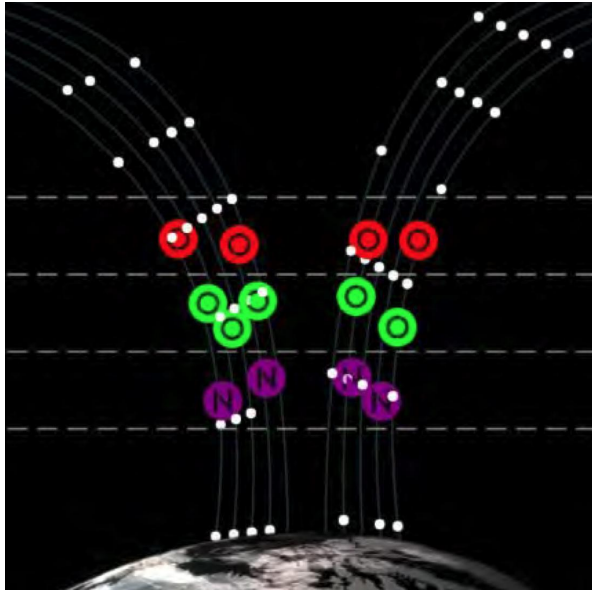
Aurora Colors



Aurora Colors *Credit: UAF*

Red is caused by energized **oxygen (O)** **high** in the **ionosphere**.

Green is created by energized **oxygen (O)** in the **middle** of the **ionosphere**.

Purple is caused by energized **nitrogen (N)** in the lower **ionosphere**.

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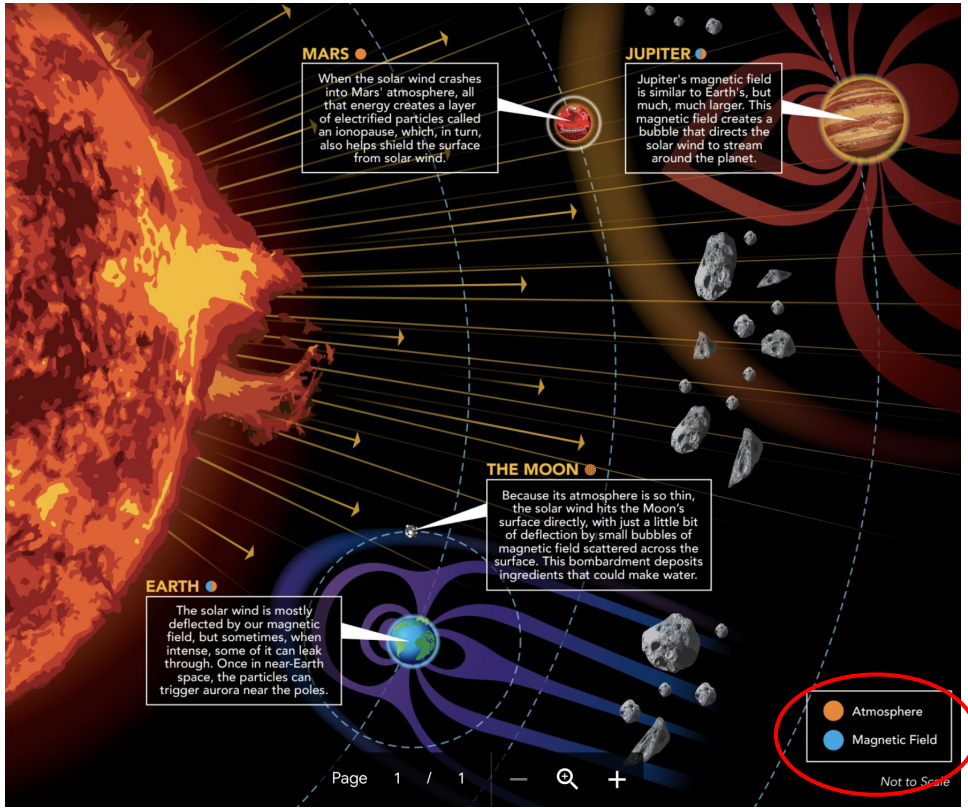
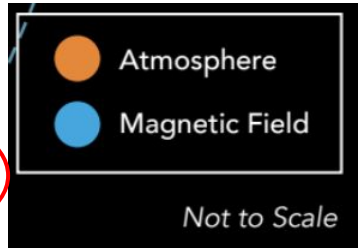
Solar Wind Across the Solar System



Credit: NASA GSFC /Mary Pat Hrybyk-Keith

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 aurora?



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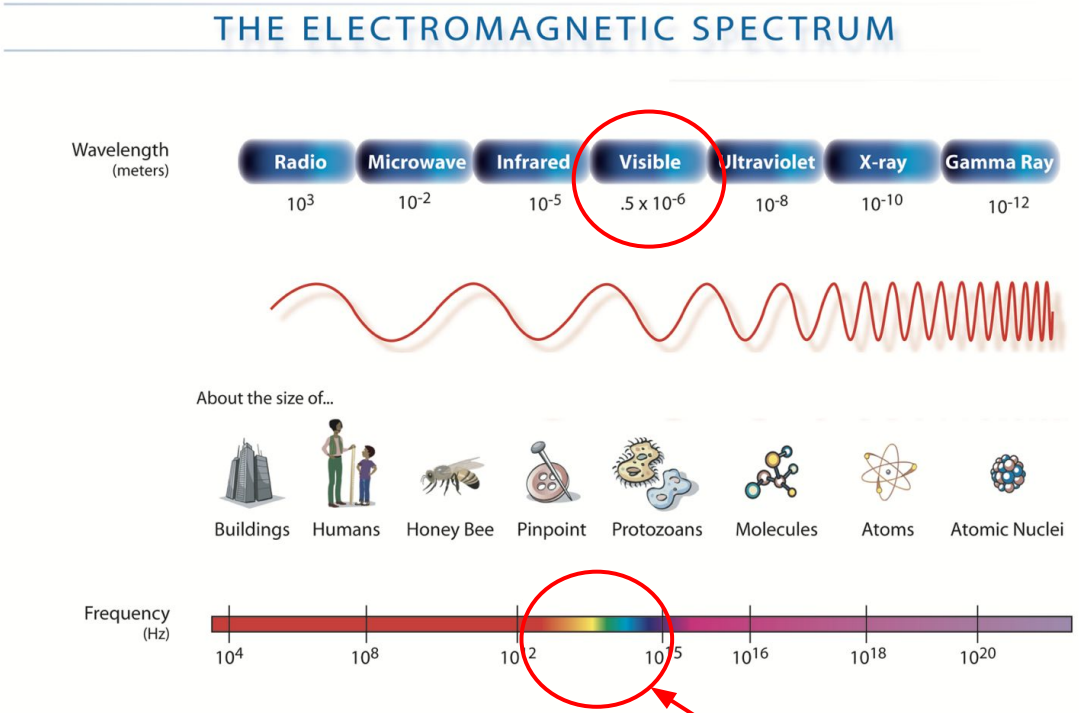
EM Spectrum



Credit: NASA / Afterschool Universe

Light is information.

Different kinds of light give us different information.

This is the only part we can see with our eyes.

Spectroscope

A **spectroscope** is a tool that separates light by different wavelengths, which helps scientists to learn more about the object they are studying.

This is similar to how a prism separates white light into all colors of the rainbow. Like a prism, the light you will be collecting and separating with the spectroscope is **visible light.**

EACH COLOR OF VISIBLE LIGHT EMITS A DIFFERENT WAVELENGTH OF LIGHT.

R E D	long wavelengths
BLUE	short wavelengths

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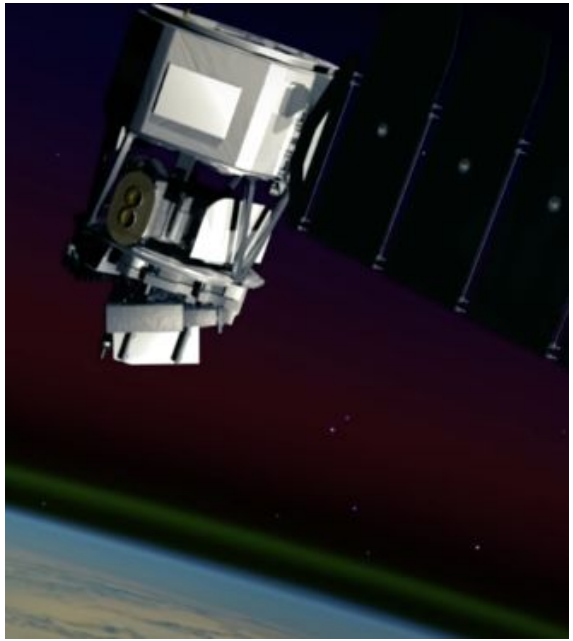
NASA Ionospheric Connection Explorer (ICON)



NASA ICON Visualization *Credit: NASA*

The NASA ICON mission uses **spectroscopes** to study the **ionosphere** by capturing images of oxygen glowing in the upper **atmosphere.**

Spectroscope Construction

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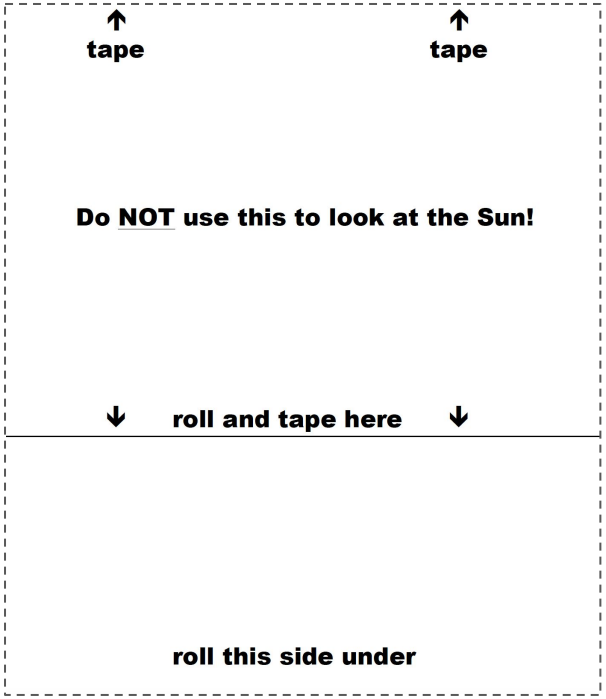
Materials:

- ❑ (1) Paper towel tube
- ❑ (1) Diffraction grating
- ❑ Aluminum foil (1 sheet, ~10” x 10”)
- ❑ Scissors
- ❑ Tape

If you don’t have a paper towel tube, you can use the Printable Spectroscope Template, or tear out **page 65** in your NASA Helio Youth Guide.

Roll it into a tube following the directions on the template. Tape to secure.



Spectroscope Template
Credit: NASA Afterschool Universe

Diffraction Grating - plastic film ruled with parallel lines that diffract (bend) light

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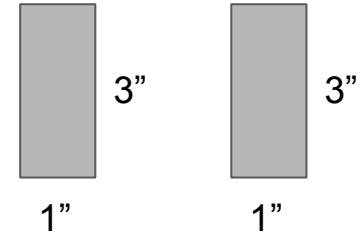
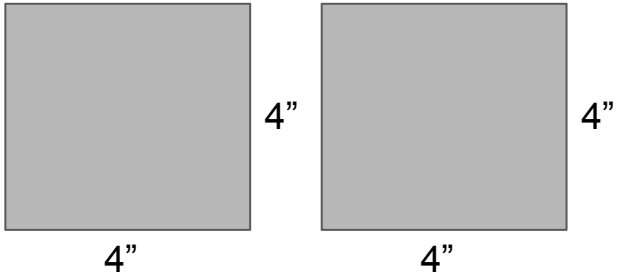
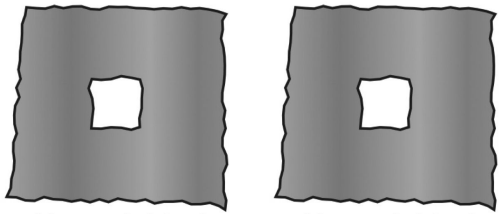
Spectroscope: Build

1. Cut two small 1” x 3” strips of aluminum foil and two 4” x 4” square pieces.





2. 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.



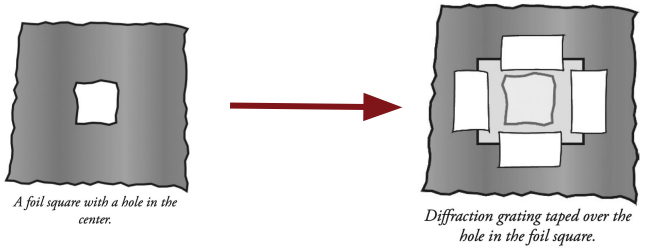
A foil square with a hole in the center.

A foil square with a hole in the center.

Credit: NASA / Afterschool Universe

Spectroscope: Build

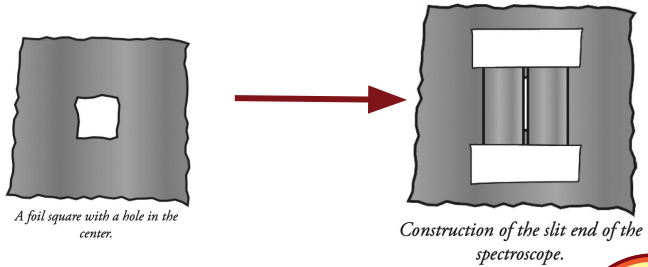
3. Tape the **diffraction grating** over the hole of one of the 4” x 4” pieces of foil.



Diffraction Grating End
(eye piece)

4. Fold two of the smaller 3”x1” strips of foil in half lengthwise.

5. Tape the folded foil strips over the hole on the other 4” x 4” piece of foil, creating a **slit** about the width of the edge of a coin. **The slit is very small.**



Slit End
(light collector)

Credit: NASA / Afterschool Universe

Spectroscope: Assemble

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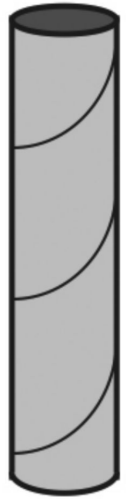
Diffraction Grating End



Paper Towel Tube

Don’t tape this end down yet.

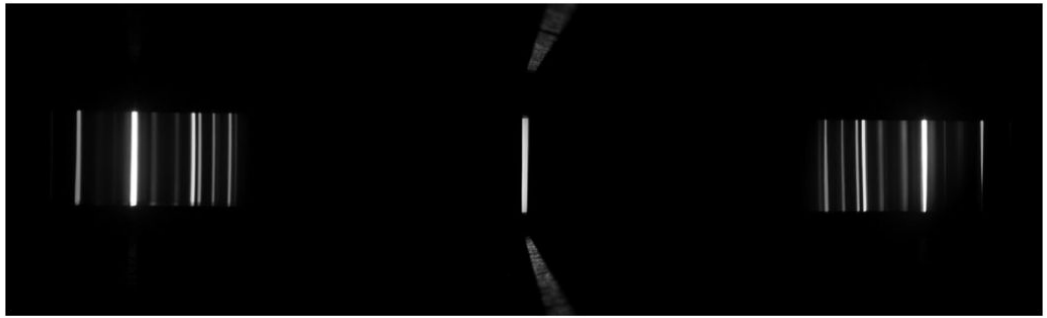
Slit End

Credit: NASA / Afterschool Universe

Align the Spectroscope

Before taping the slit end down, you need to align the spectroscope so you can see nice, orderly lines like the image below.

Each element has its own "barcode" of spectral lines.



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.

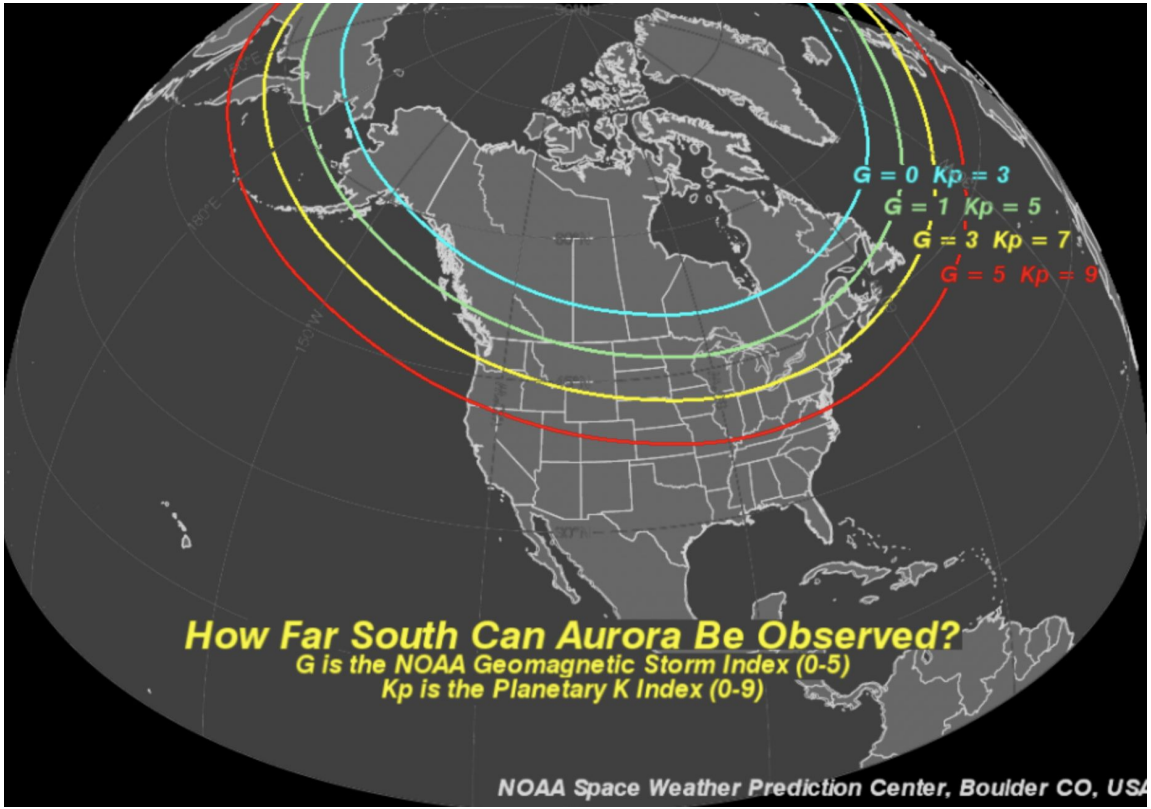
Credit: NASA / Afterschool Universe

Experiment with the Spectroscope

Use your spectroscope to analyze different lights around your house.

- Many bulbs now are light-emitting diodes (LEDs), which don't produce the full spectrum of visible light, but if you have old **fluorescent bulbs** in your house, they show a more complete spectrum.
- 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.

Aurora Kp Map of North America (NOAA)



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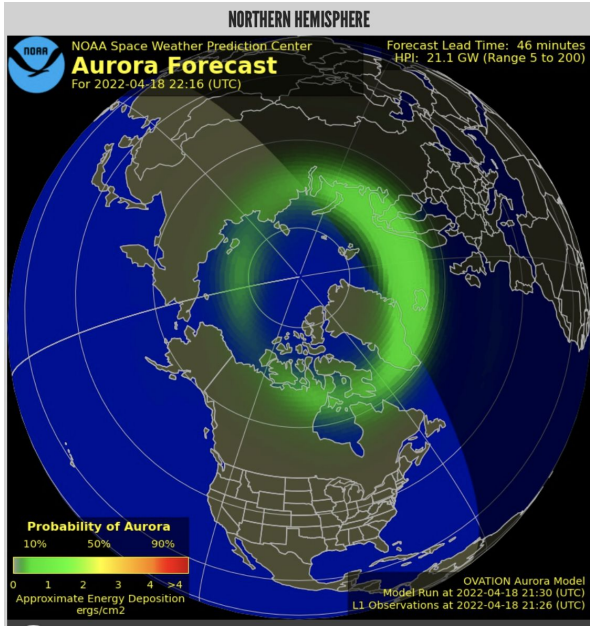
30-Minute Aurora Forecast (NOAA)

[30-minute Aurora Forecast]

- 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?



Credit: NOAA

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Make an Aurora Bracelet

Make sure your beads are strung 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.

Image Credit: UAF

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Make an Aurora Bracelet

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!

Image Credit: UAF

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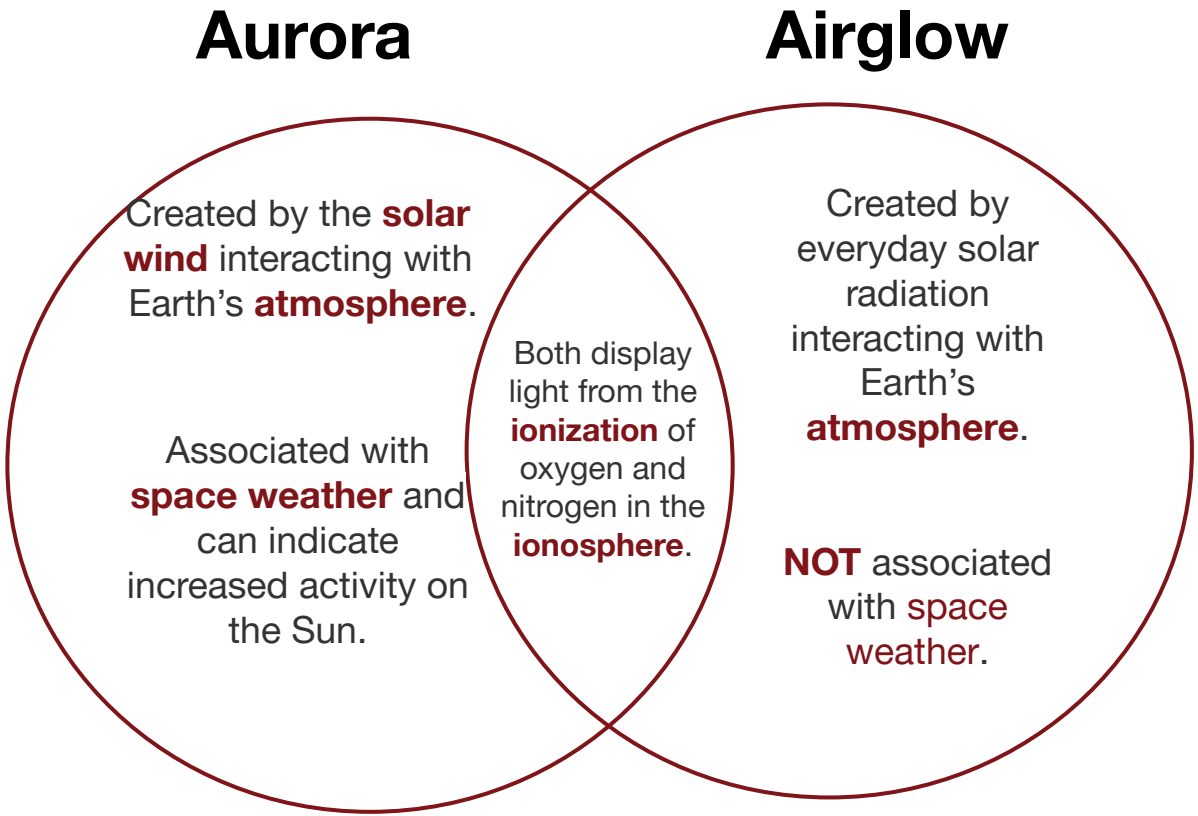
Video: Meet NASA's Ionospheric Connection Explorer (ICON)

NASA ICON Visualization *Credit: NASA*


Aurora
Airglow
Created by the **solar wind** interacting with Earth's **atmosphere**.
Associated with **space weather** and can indicate increased activity on the Sun.
Both display light from the **ionization** of oxygen and nitrogen in the **ionosphere**.
Created by everyday solar radiation interacting with Earth's **atmosphere**.
NOT associated with space weather.

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What did you learn about aurora?

Session 5: KWL		
K - what do we already know?	**W- what do we wonder about?**	**L- what did we learn?**
What do we already know about the Aurora Borealis, also known as the Northern Lights? What is it? What causes it?	**Record questions you have about the Aurora Borealis in this column.**	**Record what you learned about the Aurora Borealis in this column.**

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Session 5 Major Concepts

- ★ **Aurora** displays occur when the **solar wind** interacts with 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 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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