

## The Mysteries of Light (Part 1 of 3):

[Adapted from the SOFIA Mission's *Sensing the Invisible: Hearing Light*]

### What is it?

The Electromagnetic Spectrum is more than what we can see. X-Rays, Infrared light, and even Radio Waves are different regions of the Electromagnetic Spectrum. Without radiation like this, we would not be able to see, feel warmth, or even hear! There are several missions at NASA that use different regions of the Electromagnetic Spectrum to perform their research. The Stratospheric Observatory for Infrared Astronomy (SOFIA) uses infrared light (which we perceive as heat). The Lunar Atmospheric Dust Environment Explorer (LADEE) will use spectral analysis to learn more about the very thin, but very common lunar atmosphere. The Interface Region Imaging Spectrograph (IRIS), with even spectrograph in its name, will use this tool to uncover new information about layers of the Sun that we know nothing about. In short, the Electromagnetic Spectrum offers scientists and engineers much information about the Universe!

In this first activity, students will explore the relationship between visible light and infrared light by “hearing” what each color in the visible spectrum.

### Materials (per class):

Equipment, provided by NASA:

- Diffraction grating

Equipment, not provided by NASA:

- Overhead projector
- Two pieces of cardboard

### Materials (per team of 4 students):

Equipment, provided by NASA:

- Photocell and amplifier kit

Equipment, not provided by NASA:

- Flashlight
- *Optional: various electronics remotes*

Printables:

- Printout of electromagnetic spectrum

<http://mynasadata.larc.nasa.gov/science-processes/electromagnetic-diagram/>

**Materials (per student):**

Printables:

- Hearing Sound Worksheet

**Artifact included in this kit:**

- SOFIA Rubber Kit:
  - o Regular Rubber Ball
  - o Specialized Rubber Ball (similar to stabilizing material used on SOFIA)
  - o Information Sheet

**Recommended Speakers from Ames:**

*Please note that our Speakers Bureau program is voluntary and we cannot guarantee the availability of any speaker. To request a speaker, please visit <http://speakers.grc.nasa.gov>.*

Dana Backman (Education and Public Outreach, SOFIA)

Brian Day (Education and Public Outreach, LADEE)

Rebecca Green (Education and Public Outreach, IRIS)

**Set-Up Recommendations:**

- Prepare copies of **Hearing Sound Worksheet** for students
- Have at least one printout of the electromagnetic spectrum (website above)
- Set out supplies for each team (photocell kit)
- Set up the projector at the front of the room. It may require some experimentation, but the best way to set up the projector is to create a small slit with two pieces of cardboard (see image below).



### Procedure:

1. Introduce the concept of the electromagnetic spectrum to students with a discussion. Ask students what they know about the electromagnetic spectrum. Did they know that X-Rays (what doctors use to look for broken bones) are a particular section of the electromagnetic spectrum? Ask students to take a look at their printout of the electromagnetic spectrum. This shows all of the different waves (designated by wavelength) and what size they would be if you could see the waves. Ask if they recognize some other words (radio waves, for example) and how they think we perceive those waves (with our ears, for example).
2. Introduce the activity. Students will use the electricity generated by a photocell (which absorbs radiation to make electricity; a solar panel) to “listen” to different forms of light.
3. Split the class into teams of 4 students per team. Pass out copies of the **Hearing Light Worksheet**. Have them answer questions 1.
4. Have students assemble the photocell amplifier (see image below).



5. Have students shine a flashlight on the photocell. What do they hear? Have them describe the sound on their **Hearing Sound Worksheet**, question 2.
6. Remind students that the flashlight is “white” light, which is an assembly of all of the colors of the rainbow. Shine the projector on a blank wall in the classroom. Have students place their photocell in different areas of the spectrum and fill out the “Description” column of the chart in question 3 of their **Hearing Sound Worksheet**. Please note that “Before Red” is to indicate the dark area next to red. Two are left blank for their experimentation.
7. Discuss the results. Did students hear anything to the left of Red (the Infrared region)? Why would they hear something there? The Infrared part of the spectrum is right next to red, but we cannot see it (Infrared means “before red”).
8. *Optional: Expand on their experience by having students point some of the various remotes at the photocell, pressing one of the buttons. Why, after performing this experiment, do you think a Sony remote does not work for a Toshiba television?*

### Helpful Resources:

NASA Electromagnetic Spectrum:

[http://imagine.gsfc.nasa.gov/docs/science/know\\_l1/emspectrum.html](http://imagine.gsfc.nasa.gov/docs/science/know_l1/emspectrum.html)

NASA’s SOFIA Mission:

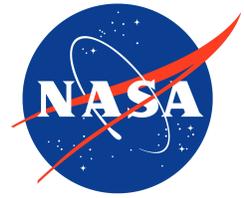
<http://www.nasa.gov/sofia>

NASA’s LADEE Mission:

<http://www.nasa.gov/ladee>

NASA’s IRIS Mission:

<http://www.nasa.gov/iris>



**Name:** \_\_\_\_\_

### Hearing Sound Worksheet

1. Which section of the electromagnetic spectrum do we perceive as heat? Which do we perceive as sound?
  
2. Describe the sound when you shined the flashlight on the photocell.
  
3. Use the chart below for your photocell experiments. Place your photocell in the area indicated below. Describe what you hear in the adjacent column.

Area	Description
Red	
Blue	
Before Red	



## **The Mysteries of Light (Part 2 of 3):** **[Adapted from NASA's *The Electromagnetic Spectrum*]**

### **What is it?**

The Electromagnetic Spectrum is more than what we can see. X-Rays, Infrared light, and even Radio Waves are different regions of the Electromagnetic Spectrum. Without radiation like this, we would not be able to see, feel warmth, or even hear! There are several missions at NASA that use different regions of the Electromagnetic Spectrum to perform their research. The Stratospheric Observatory for Infrared Astronomy (SOFIA) uses infrared light (which we perceive as heat). The Lunar Atmospheric Dust Environment Explorer (LADEE) will use spectral analysis to learn more about the very thin, but very common lunar atmosphere. The Interface Region Imaging Spectrograph (IRIS), with even spectrograph in its name, will use this tool to uncover new information about layers of the Sun that we know nothing about. In short, the Electromagnetic Spectrum offers scientists and engineers much information about the Universe!

In this first activity, students will build their own spectroscope out of a cereal box.

### **This activity discusses topics related to National Science Education Standards:**

*MS-PS4.B-3: A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.*

- This activity encourages students to think about the usefulness of light when trying to determine facts about the Earth and beyond.

### **Materials (per student or team):**

Equipment, provided by NASA:

- Diffraction grating

Equipment, not provided by NASA:

- Cereal box
- Tape
- Aluminum foil
- Marker
- Ruler
- Scissors
- Blade Knife
- Cutting tubes

### **Artifact included in this kit:**

- SOFIA Rubber Kit:

- Regular Rubber Ball
- Specialized Rubber Ball (similar to stabilizing material used on SOFIA)
- Information Sheet

### **Recommended Speakers from Ames:**

*Please note that our Speakers Bureau program is voluntary and we cannot guarantee the availability of any speaker. To request a speaker, please visit <http://speakers.grc.nasa.gov>.*

Dana Backman (Education and Public Outreach, SOFIA)

Brian Day (Education and Public Outreach, LADEE)

Rebecca Green (Education and Public Outreach, IRIS)

### **Set-Up Recommendations:**

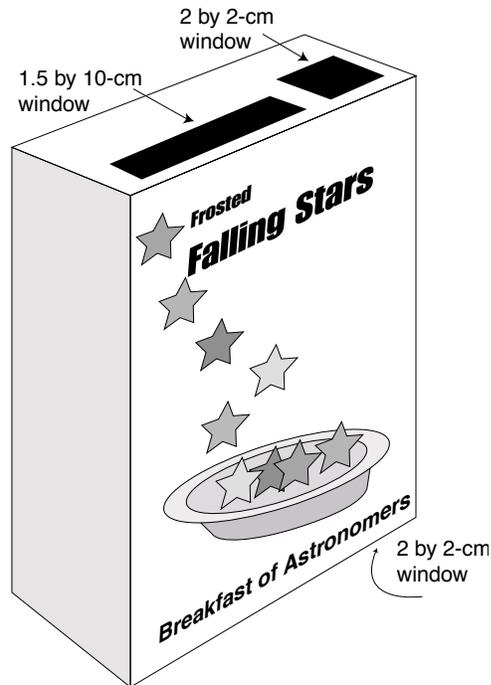
- Set out supplies for each team
- Set up the spectrum tubes at the front of the room. Please take a moment to read the directions included in the box for safe handling instructions.
- Copy the ruler (located on the last page of this document) on projector transparency. Numerous rulers are printed and positioned on the sheet.

### **Safety:**

- Please do not allow students to handle the spectrum tubes. The tubes should only be handled by the teacher or an adult.
- Please use proper safety in regards to scissors and the blade knife.

### **Procedure:**

1. Introduce the concept of the spectrograph to students with a discussion. We know now that the electromagnetic spectrum is broken into different sections. The visible part of the spectrum, albeit small, can still tell us quite a bit about objects in space. When an atom's electron moves from one level to another level, it absorbs or releases a photon (a particle of light) at a very particular wavelength. Because these movements happen all the time in atoms, each element has a very specific fingerprint of wavelengths that are emitted or absorbed (called an emission spectrum or absorption spectrum). Scientists use these spectrum to identify elements on Earth and in the Universe.
2. Introduce the activity. Students will build their own spectrograph.
3. Split the class into teams, if desired, or have each build their own.
4. Have each student cut a 2 by 2-centimeter window from the bottom lid of the cereal box near one side.
5. Cut an identical 2 by 2-centimeter window on the top of the box directly above the previous window.
6. Cut a 1.5 by 10-centimeter window in the upper lid (see below image).



7. Place the diffraction grating over this large window. Please note that the grating can be easily smudged, and so try to handle it only by the edges.
8. Using lights in the room, have students adjust the grating so that they can see rainbow colors to the right and left of the grating when looking through the bottom window. Tape the grating in place.
9. Cut a 4 by 4-centimeter piece of aluminum foil and place on a cutting surface.
10. Using the blade knife, cut a narrow slot in the foil (this step may want to be handled by an adult).
11. Tape the foil over the top window (next to the diffraction grating). The slot should be positioned directly over the hole and aligned perpendicular to the cereal box front.
12. Place one of the transparency rulers over the diffraction grating and tape into place. Students should be able to read the numbers of the ruler with 400 on the right and 700 on the left.
13. Have students calibrate the spectroscope using the following steps:
  - i. Aim the slot end of the spectroscope toward a light.
  - ii. If the rainbow appears as a narrow rainbow colored line, remove the grating and rotate it 90 degrees and re-tape.
  - iii. Green is between 540 and 550 micrometers, so move the ruler so that green falls between 540 and 550 on your diffraction grating.
  - iv. Tape the ruler in place.
14. Have students store their spectrographs for the next activity.

### Helpful Resources:

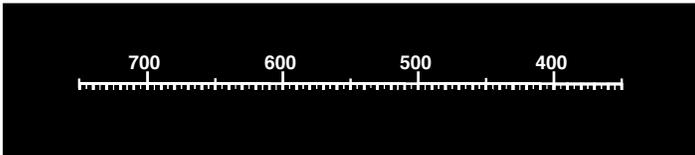
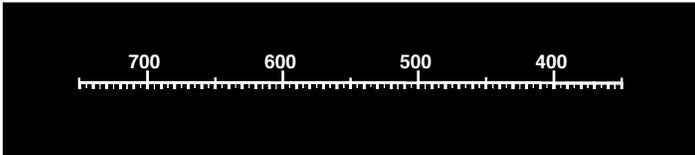
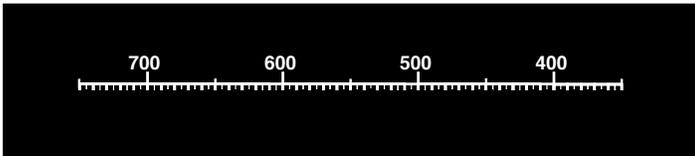
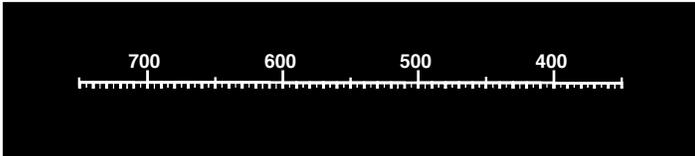
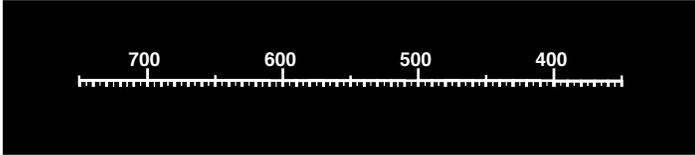
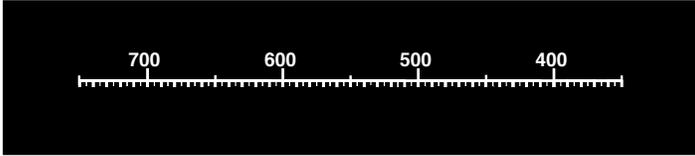
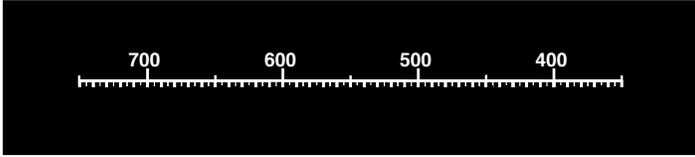
NASA Electromagnetic Spectrum:

[http://imagine.gsfc.nasa.gov/docs/science/known\\_11/emspectrum.html](http://imagine.gsfc.nasa.gov/docs/science/known_11/emspectrum.html)

NASA's SOFIA Mission:  
<http://www.nasa.gov/sofia>

NASA's LADEE Mission:  
<http://www.nasa.gov/ladee>

NASA's IRIS Mission:  
<http://www.nasa.gov/iris>





## **The Mysteries of Light (Part 3 of 3):** **[Adapted from NASA's *The Electromagnetic Spectrum*]**

### **What is it?**

The Electromagnetic Spectrum is more than what we can see. X-Rays, Infrared light, and even Radio Waves are different regions of the Electromagnetic Spectrum. Without radiation like this, we would not be able to see, feel warmth, or even hear! There are several missions at NASA that use different regions of the Electromagnetic Spectrum to perform their research. The Stratospheric Observatory for Infrared Astronomy (SOFIA) uses infrared light (which we perceive as heat). The Lunar Atmospheric Dust Environment Explorer (LADEE) will use spectral analysis to learn more about the very thin, but very common lunar atmosphere. The Interface Region Imaging Spectrograph (IRIS), with even spectrograph in its name, will use this tool to uncover new information about layers of the Sun that we know nothing about. In short, the Electromagnetic Spectrum offers scientists and engineers much information about the Universe!

In this first activity, students will use their cereal box spectrographs to guess elements.

### **This activity discusses topics related to National Science Education Standards:**

*MS-PS4.B-3: A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.*

- This activity encourages students to analyze light spectra to try to draw conclusions about identifying a gas.

### **Materials (per class):**

Equipment, provided by NASA:

- Spectral tubes and power source

### **Materials (per student or team)**

Equipment, not provided by NASA:

- Cereal box spectrograph (completed in Part 2)

Printables:

- Mystery Element Worksheet
- Spectra of Common Elements Sheet

### **Artifact included in this kit:**

- SOFIA Rubber Kit:
  - o Regular Rubber Ball

- Specialized Rubber Ball (similar to stabilizing material used on SOFIA)
- Information Sheet

### **Recommended Speakers from Ames:**

*Please note that our Speakers Bureau program is voluntary and we cannot guarantee the availability of any speaker. To request a speaker, please visit <http://speakers.grc.nasa.gov>.*

Dana Backman (Education and Public Outreach, SOFIA)

Brian Day (Education and Public Outreach, LADEE)

Rebecca Green (Education and Public Outreach, IRIS)

### **Set-Up Recommendations:**

- Set up the spectrum tubes at the front of the room. Please take a moment to read the directions included in the box for safe handling instructions. Set up Helium, Hydrogen and Argon with labels above, but leave Water Vapor without a label (this will be our mystery element).

### **Safety:**

- Please do not allow students to handle the spectrum tubes. The tubes should be handled by the teacher or an adult.

### **Procedure:**

1. Introduce the concept of the spectroscopy to students with a discussion. We now know that different elements emit spectra when their atoms' electrons move levels [we have included a resource below if you wish to explain the movement of electrons within atoms further]. The photons that are emitted are of a very specific wavelength, and so spectra of different elements are very specific, almost like a fingerprint. Scientists use these "fingerprints" to identify gasses in other objects, both on Earth and in space.
2. Introduce the activity. Students will view and observe the spectra of different known elements, and then using their knowledge, try to guess a mystery element.
3. Split the class back into their teams (if applicable) or have them work individually.
4. Pass out copies of the **Mystery Element Worksheet** and have students answer question 1.
5. Turn on the Helium, Hydrogen and Argon lamps. Have students draw what they see through their cereal box spectrographs on question 2 of their **Mystery Element Worksheet**. They need not color the lines, but simply mark where they see them.

6. Now it's time for the mystery element. Have students look at the mystery tube using their spectrograph and mark the lines they see on their **Mystery Element Worksheet**. Have students compare to the other spectra they drew (they should see a slight similarity between the Hydrogen tube and the mystery element).
7. Have students look at the **Spectra of Common Elements Sheet** and compare to what they saw with their spectrograph. Have students write down their guess on their **Mystery Element Worksheet**.
8. Take a poll of the students guesses and write them on the front board.
9. Reveal the mystery element: water vapor. Have students answer question 4 on their **Mystery Element Worksheet**.

### **Helpful Resources:**

NASA Electromagnetic Spectrum:

[http://imagine.gsfc.nasa.gov/docs/science/know\\_l1/emspectrum.html](http://imagine.gsfc.nasa.gov/docs/science/know_l1/emspectrum.html)

NASA's SOFIA Mission:

<http://www.nasa.gov/sofia>

NASA's LADEE Mission:

<http://www.nasa.gov/ladee>

NASA's IRIS Mission:

<http://www.nasa.gov/iris>

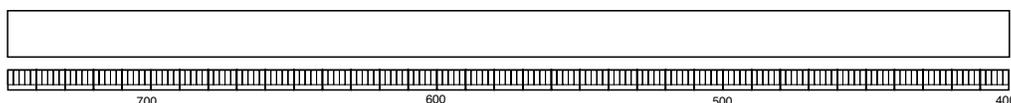


Name: \_\_\_\_\_

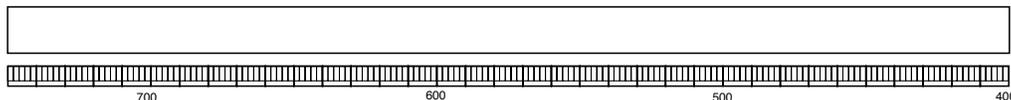
### Mystery Element Worksheet

1. Why can scientists determine different elements by looking through a diffraction grating?
2. Draw what you see from the spectral tubes:

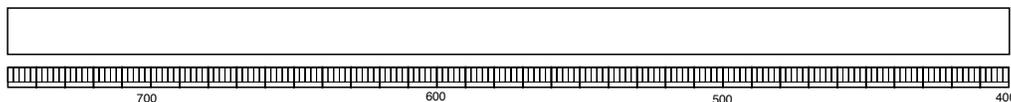
Helium:



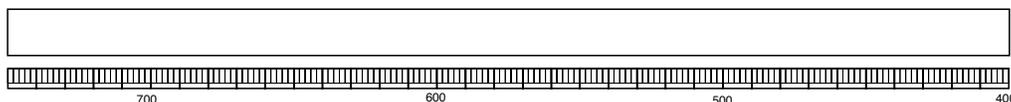
Hydrogen:



Argon:



Mystery Element:



3. What do you think the mystery element is?
4. Was your guess correct? If so, what do you think worked when making this guess? If not, describe where you think you might be able to improve.

## Common Element Spectra

**Hydrogen:**



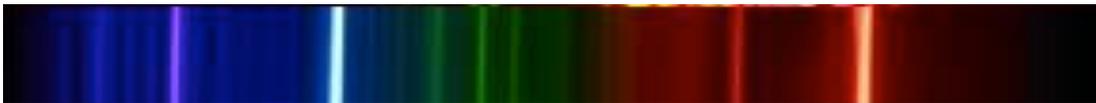
**Helium:**



**Oxygen:**



**Water Vapor:**



**Carbon:**



**Argon:**

