Decoding Starlight Exhibit Guide

Teacher Edition (B)

This teacher edition provides much more detailed information than what the students are expected to learn. We provide this information to provide more background that may help you enrich interactions between you and your students.

Star Light, Star Bright

Do you see a bright light high on the wall?

The bright disk above the color spectrum is an image of the Sun, projected by the heliostat. Look closely – you will probably see sunspots! The dark vertical line is the slit where sunlight enters the Solar Spectrum Projector.

Where is the light coming from?

The light is coming from the Sun. Students may notice the heliostat and think it is coming from "that projector." The heliostat gathers the sunlight and sends it to the Solar Spectrum Projector. You can see the sunbeam above your head if you stand by the exhibit introduction panel in the lobby.

How is the Sun's spectrum like a rainbow?

The bright band of color below the Sun's image is the Sun's spectrum. It contains the same colors as a rainbow.

How is it different?

Inside the solar spectrum are darkened vertical lines.

> Astronomers call these absorption lines because atomic elements in the Sun have absorbed light of a particular wavelength (color), then emitted light of the same wavelength in another direction away from the heliostat. So the beam of sunlight that enters the heliostat is dimmer for these wavelengths that then appear in the spectrum as dim color features.

This solar spectrum is spread straight out horizontally instead of an arc or bow like a rainbow.

> Tiny water drops spread out the colors of sunlight much like a prism. Both a prism and water drop refract light, which changes the direction the light travels according to its wavelength (color). However, a grating inside the Solar Spectrum Projector produces a spectrum via different processes: diffraction and interference.

STAR LIGHT, STAR BRIGHT

Do you see a bright light high on the wall?
Where is the light coming from?

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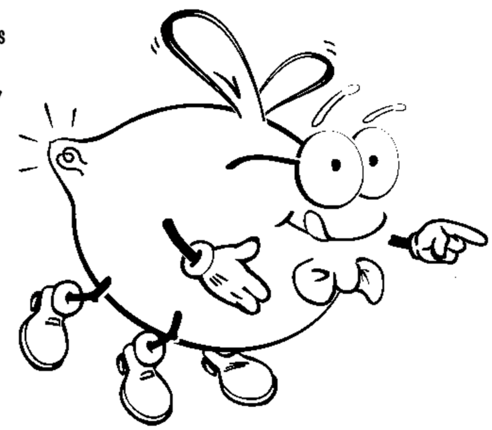
Look at the colors of the spectrum. Color Mac's body the colors that you see.



How is the Sun's spectrum like a rainbow?

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How is it different?

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Related TEKS: 3.11, 5.8
Related NSES: K - 4 Physical Science: properties of objects and materials; light.
5 - 8 Physical science: transfer of energy.

What are the big ideas?

The Sun is a star. Light that we can see is actually composed of many colors. A grating or a prism can separate the colors so that an astronomer can examine the colors.

Connections to other domains and everyday life

Refraction and interference produce color spectra:

- Refraction
  - Rainbow: water refracts sunlight during an afternoon or morning rain shower. A fine water mist from a garden hose on a sunny day produces a mini-rainbow.
- Interference
  - Flowing colors on bubbles, or an oil slick on wet road: light reflected off the thin film surface interferes constructively and destructively with light reflected from the water surface (or bottom surface of the bubble). We see the interference pattern as a spectrum of color.
  - Color spectrum reflected from CDs and DVDs: produces an interference pattern due to a tight closely spaced spiral track dotted with shallow pits. A thin reflective layer of aluminum covers the spiral track of pits. Together, the spiral track and aluminum coating reflect to your eye a colorful interference pattern.

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Every Star has a Spectrum

Slide the grating over the star pictures. What happens?

Tiny spectra appear that surround each star.

How many spectra do you see for each star?

The star appears between two spectra, with violet closest to the star and red farthest away on each side.

What's Out There?

Jupiter is the only "Inside the Solar System" object. All the remaining objects are located far outside our solar system. Some objects, like "Eagle Nebula, M45" have a common name and a catalog name. In this case, the nebula's shape looks like an eagle. The same nebula is listed in Messier's catalog as 16, or in the New General Catalog as 6611.

"M" stands for Charles Messier. He assembled a catalog of 110 objects that might be mistaken for comets (he was a comet-hunter). "NGC" stands for New General Catalog of Non-stellar Objects. John Herschel cataloged the positions and descriptions of thousands of nebulae and star clusters. The first NGC was published in 1887. Astronomers today use an updated version of the NGC.

Big Ideas:

Light from the Sun and other stars spreads out into a spectrum of many colors. Celestial objects like nebulae (gas and dust), planets, and star clusters also have spectra. The pattern of absorption and/or emission lines in a spectrum is clues about the physical properties of celestial objects.

Explain:

Color vs. wavelength: Light is an electromagnetic wave. And like all waves, light has a wavelength and frequency. Astronomers quantify wavelengths of visible light in tiny units called Angstroms (10^{-10} meters) or nanometers (10^{-9} meters). We perceive a narrow range of light wavelengths as color, from red (longest wavelength ~ 7000 Angstroms) to violet (shortest ~ 4000 Angstroms).

Emission line vs. absorption line: A bright (emission) or diminished (absorption) sliver of color in a spectrum produced by a spectroscope or spectrograph. Astronomers interpret these lines as clues about what is happening inside a celestial object, or its physical properties (temperature, composition, size, etc.). For instance, we know that each atomic element produces a unique pattern of emission or absorption lines. An astronomer can infer that a star contains an element, like hydrogen, if he or she sees hydrogen's signature pattern of lines in the star's spectrum. A line is an emission line if it is glowing against a dark background, or an absorption line if it appears against a brighter (hotter) background. A hot gas cloud produces emission lines. Cool gas in front of a hot star produces absorption lines.

SECRETS OF STARLIGHT

★ ***Every Star has a Spectrum***

Like the Sun, every star has a spectrum.
Slide the grating over the star pictures. What happens?

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How many spectra do you see for each star?

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★ ***What's Out There?***

When you look up at night, most of the lights are stars. With a telescope, you can see that some are different.
Press a button on the big sky map, and then look at the monitor.
Fill out the table with five different things you see.

Inside our Solar System	Outside our Solar System
1.	Eagle Nebula, M16
2.	
3.	
4.	
5.	

Object	Where is it?	What is it?
Jupiter	Inside	5th planet from the Sun
Eagle Nebula, M16	Outside	emission nebula
M4	Outside	globular star cluster
Butterfly Cluster, M6	Outside	open star cluster
Ptolemy's Cluster, M7	Outside	open star cluster
Lagoon Nebula, M8	Outside	emission nebula
Trifid Nebula, M20	Outside	reflection nebula
M22	Outside	globular star cluster
NGC 6537	Outside	planetary nebula
NGC 6578	Outside	planetary nebula
Pipe Nebula, Barnard 78	Outside	dark nebula

Related TEKS: 3.11, 5.8
Related NSES: K - 4 Physical science: properties of objects and materials, light.
5 - 8 Physical science: transfer of energy.

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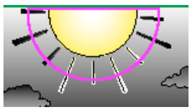
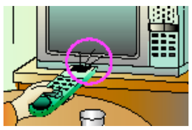
Light in Everyday Life

What happens when you move the selector to different positions?

Each picture panel represents an object that emits light within one of the wavelength regions. The picture panels that correspond to the selected electromagnetic radiation wavelength region light up. For instance, when students select the infrared wavelength region, four panels will light up:



- Sun: The Sun emits light throughout the electromagnetic spectrum (all the wavelength regions of this exhibit). The Sun emits the most light in the visible region of the electromagnetic spectrum.



- Television remote control: Television remote control units send instructions to the television as infrared pulses of light.

- Electric oven range: Electricity flowing through the heating element coil raises the temperature of the metal in the coil. As the coil's temperature begins to rise, it emits light in infrared. At high temperatures, the coil will also emit visible light in deep red to orange colors.

- Children walking a dog: People and animals emit infrared light. The faces of the children are circled because that is where the infrared light would be brightest. Their coats would insulate their bodies and block infrared light.

What can your eyes detect?

Our eyes are sensitive to the visible region of t electromagnetic spectrum. We perceive this narrow portion of the entire electromagnetic spectrum as color.

Which picture panel remains "on" for any wavelength section?

The Sun emits light in all the regions of the electromagnetic spectrum. However, the amount of energy that the Sun emits in each wavelength region varies. The Sun emits most of its energy as light in the visible region of the spectrum.

★ *Light is More Than Meets the Eye: Light in Everyday Life*

Our eyes alone can see a small part of the whole electromagnetic spectrum.

Objects in the universe shine at many wavelengths:
Gamma ray • x-ray • ultraviolet • visible • infrared • microwave • radio

What happens when you move the selector to different positions?

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What can your eyes detect?

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Which picture panel remains "on" for any wavelenth section?

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Why?

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★ *Star Codes: Patterns in Starlight*

Press and hold down the hydrogen or sodium button, then look into the window. Try both buttons together.
Have you seen any of these color patterns?

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Where?

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Related TEKS: 5.8, 6.8
Related NSES: 5 - 8 Physical science: transfer of energy.

Star Codes: Patterns in Starlight

Have you seen any of these color patterns? Where?

The patterns of emission lines corresponding to hydrogen are found in most of the spectra throughout the exhibit. For instance, these are some of the most prominent absorption lines in the Sun's spectrum, which indicates that the Sun contains hydrogen. Some stars, like Vega and Sirius, show very strong hydrogen absorption features in their spectra. Many of the objects in the "What's Out There?" exhibit section also show strong hydrogen absorption or emission features in their spectra.

Connections to other domains and everyday life

- Spectroscopy is a powerful tool in everyday life. One example is tracing the origin of paint chips left at the scene of an hit-and-run automobile accident. Automobile paint contains a recipe of rare elements. Using spectroscopy, police officers can analyze the accident scene paint chips to find their recipe, and compare to samples paint chips of suspect vehicles.
- The US Geological Survey uses spectroscopy to map vegetation and geological features. Vegetation covers a large portion of Earth's land surface, but is hard to map because most healthy plants are chemically similar and look like various shades of green. Imaging spectroscopy is a new mapping tool in remote sensing that allows scientists to distinguish the subtle chemical differences. To gather the data, NASA has flown an infrared scanning spectrometer over remote territory, such as Yellowstone National Park.

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Teacher Edition (B)

Gathering Starlight

Behind the Scenes at McDonald Observatory

GATHERING STARLIGHT

★ *Behind the Scenes at McDonald Observatory*

Many people work at McDonald Observatory. They all work together with astronomers to make the Observatory a place for science and wonder.

"Look carefully at the different places and people of McDonald Observatory. Can you see similarities between the town or city where you live and McDonald Observatory?"
Draw a picture of how they are alike.

Related NSES: 5 - 8 History and nature of science: science as a human endeavor.

This exhibit highlights the team of people that run McDonald Observatory. Operating and managing an observatory requires a diverse group of dedicated and talented people from diverse backgrounds and expertise. In many ways, the Observatory resembles a small town.

McDonald Observatory's "Main Street" connects all the major facilities together. McDonald Observatory's "Main Street" begins at Highway 118, continues past the Visitors Center, winds up Mount Locke, circles the summit, and ends at the Harlan J. Smith 2.7-meter Telescope dome. Along the way are the places and facilities that compose McDonald Observatory.

Just like many small towns and cities, McDonald Observatory welcomes visitors with a large landscaped sign where "Main Street" begins. On the right is the McDonald Observatory Visitors Center where guests can learn about the Observatory and astronomical research. Further up is a road running by the firehouse and into the main residential area of the Observatory. Notice the park and swimming pool as you drive by. You may also see the school bus that carries children who live here from the Observatory to nearby Fort Davis schools.

As the "Main Street" wanders up the side of Mt. Locke, you can get a better look at the Visitors Center and residential area below. The spur road on the left leads to the Hobby-Eberly Telescope and the Laser Ranging Station. Just a bit further up, "Main Street" enters "downtown" McDonald Observatory. Much like a town square, the road circles the summit of Mt. Locke to connect major Observatory facilities.

One of the most important places at the Observatory is the physical plant building. Staff members build new or fix existing equipment, plus maintain Observatory trucks and vehicles. The Transient Quarters (TQ) is much like the favorite town restaurant and hotel. Visiting astronomers stay at the TQ while they conduct their astronomical observations over many nights. Rounding the corner from the TQ are some of the resident's homes, beginning with the Observatory Superintendent's and Director's homes. A little way down the road are the 0.9-meter and 0.8-meter telescopes. On the east side are more homes of key members of the Observatory's technical and mechanical staff.

Finally, "Main Street" passes the Struve 2.1-meter Telescope dome, which acts like a town hall for the Observatory and stands on the summit of Mt. Locke. Inside are the Observatory's main administrative offices, including the Superintendent's office. Mailboxes for all the residents are in this building. At the end of "Main Street" stands the 2.7-meter Harlan J. Smith Telescope dome.

Since the exhibit was completed, some staff member jobs have changed.

- Mark Adams: Assistant Director of McDonald Observatory and Superintendent
- Tom Brown: Physical Plant Supervisor
- Cecilia Davis: Senior Administrative Associate
- David Doss: Research Engineering Scientist Associate
- Ed Dutchover: Assistant Superintendent, Administrative Support
- Jim Fowler: Hobby-Eberly Telescope Facility Manager
- Earl Green: Assistant Superintendent for Observing Support
- Pat Olivas: Mechanic / Technician – Carpentry
- Angie Otoupal: Retail Manager
- Robert Petty: Transient Quarters Chef and Manager
- Michael Ward: Computer Department Supervisor and Jeff Davis County Fire Marshal
- Marc Wetzel: K-12 Education Program Coordinator
- Jane Wiant: Librarian
- Jerry Wiant: McDonald Laser Ranging Station

Making Sense of the Universe

The rabbit in the center of this Mimbres Bowl replica is thought to represent the Moon. Count the arches on the rabbit's back. They number 29, close to the number of days in the Moon's phase cycle, or synodic period, which is 29.53 days. Perhaps this was one way that the Mimbres brought the heavens to Earth, and integrated the sky into their culture.

American Indians drew constellations, created starlore, and built structures in alignment with the sky long before Europeans arrived on American shores. They tracked the motions of the Sun to help them decide when to plant crops, move their camps, or stage sacred rituals. They crafted explanations for meteor showers and the northern lights, and saw a pathway to the afterlife in the Milky Way.

Some tribes built great circles of stones to help them predict the changing seasons. Others built great ceremonial centers in alignment with the Sun and stars. And still others built great mounds of earth to reflect the patterns they saw in the heavens.

All of these activities were attempts to build order into the heavens as well as their daily lives. They reflected a close bond between the people and their environment – in the sky and on the ground. And they reflected an even closer bond between the secular and the sacred: The Sun, Moon, and stars were not just physical objects following well-defined paths across the sky; they were gifts from the gods. They told the people where they came from, where they were going, and how to live their lives.

TIMELESS EXPLORATION

★ ***Making Sense of the Universe***

One thousand years ago, American Indians called the Mimbres lived close to McDonald Observatory in New Mexico. They made beautifully decorated bowls to show what was important to them.

Pretend that you are a one of the Mimbres living 1,000 years ago. Design a bowl to show something you learned today.

Related NSES: K - 4 and 5 - 8 History and nature of science: science as a human endeavor.

Resources:

Mimbres bowls: Brody, J. J. *"Mimbres painted pottery."* Santa Fe (N.M.) 1977
StarDate Native Skies: http://stardate.org/nativeskies/

Answers to questions

Students may choose to draw anything they like in the space provided. You may wish to use these drawings as a prompt for a writing assignment about their Observatory experience. It is unlikely that students of this grade level will attempt to follow the Mimbres example of linking an everyday object (the rabbit) with their conceptual understanding of the heavens. However, it is likely that the students will select an object or event that impressed them in some way. For some students, it may be the bus ride or lunch rather than something about astronomy or the community of science that they visited. Their discussion of the drawings may offer a rich opportunity to extend their Student Field Experience.