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AEROSPACE MICRO-LESSON

Easily digestible Aerospace Principles revealed for K-12 Students and Educators. These lessons will be sent on a bi-weekly basis and allow grade-level focused learning. - AIAA STEM K-12 Committee.

THE AURORA BOREALIS

Few sights in this world are as mysterious as the shimmering lights of the aurora. For those accustomed to solid, material objects that follow predictable paths, the wild and unpredictable movements of the lights in the sky evoke a wonder and awe. This lesson explores the aurora.

GRADES K-2

If you live in the far northern part of the Earth, when the night sky is clear you may be able to see moving areas of light when you look up. These glows in the sky, called the "Northern Lights" or "Aurora Borealis" ("aurora" is Latin for "dawn" and "borealis" is Latin for "of the north"), form a large ring, hundreds of miles in diameter, high in the sky around the North Pole. There is another ring, the "Southern Lights" or "Aurora Australis," around the South Pole. Fewer people live where they can see the Aurora Australis, though, and so the northern version gets more attention.

Like most nighttime displays in nature, the auroras can be easily overwhelmed by artificial lights; one needs to get away from street lights in order to see them well. It often takes some work to see an aurora; one must be in the right place at the right time and be looking in the right direction.

The Northern (and Southern) Lights are caused by the Sun. The Sun sends out not only light and heat, but also extremely small charged particles called "electrons" and "protons." The Earth's magnetic field—the thing that makes a compass needle point north-south—pushes these electrons and protons away from the Equator and toward the North and South Poles. The auroras are formed when the electrons and protons hit the upper atmosphere. From space, they look like round curtains of light around the poles.

GRADES 3-5

The Earth is not the only planet that has auroras. Think for a minute about what it takes to make an aurora. First you need to know what causes it; the K-2 lesson explains briefly that the aurora is created by particles from the Sun being pushed by the Earth's magnetic field toward the North and South Poles. The particles from the Sun come down into the Earth's

GRADES 3-5 (CONTINUED)

atmosphere in rings around the North and South Poles; where the particles hit the atmosphere, they make it glow.

With that in mind, what does it take to create an aurora? As far as we know, it takes the Sun—or something else—sending out the particles; it takes a magnetic field inside the planet itself that shields most of the planet but lets the particles in near the north and south poles; and it takes an atmosphere. Mercury has a weak magnetic field but no atmosphere so it does not have auroras. Venus has an atmosphere but no magnetic field so it does not have auroras either (although it has some unexplained lights that may be related). Mars has a weak magnetic field and a thin atmosphere and has auroras, although they are much closer to the equator than Earth's auroras (as one would expect with a weaker magnetic field). Jupiter and Saturn both have strong auroras circling their poles. Saturn's moon Titan has an atmosphere but it is entirely within Saturn's magnetic field, preventing the particles from the Sun from reaching its poles; it does not have auroras either.

Scientists do not know everything about auroras, though. While we think there need to be the particles from the Sun and the other things for an aurora to form, scientists may have discovered auroras on a "rogue planet" out in deep space which does not go around a star. Like any new discovery, this is tentative and the interpretation may change as scientists get more data.

GRADES 6-8

What does an aurora look like? That depends on the direction from which you are looking at it. From directly underneath it, the aurora can look like a luminous river flowing through the sky; from a distance, one can see only an indistinct glow. In between, not directly underneath but still fairly close, one can see what look like curtains of light in the upper atmosphere. This also is what astronauts in the Space Station see when they look at the aurora from above.

The aurora can take on several colors as well. Usually it is green, but it can also be blue, yellow, purple, or any of half a dozen other colors. These colors depend on the type of atom or molecule that the particles from the Sun are hitting. Nitrogen atoms create a blue glow while nitrogen molecules (a nitrogen molecule is made of two nitrogen atoms attached to each other) glow purple. Oxygen creates a yellow or green light.

GRADES 6-8 (CONTINUED)

This series of links gives an excellent middle-school lesson (though much larger than a micro-lesson) by NASA concerning the Northern Lights: Part 1 (people's descriptions of auroras), Part 2 (what an aurora looks like from a satellite), Part 3 (what auroras look like from different places on the ground), Part 4 (calculating how high they are I), Part 5 (calculating how high they are II), Part 6 (calculating how high they are III), Part 7 (predicting where they will appear I), Part 8 (predicting where they will appear II), Part 9 (predicting where they will appear III), Part 10 (decoding runes)

GRADES 9-12

The more elementary grade bands in this lesson describe the Earth's auroras, what causes them, where else in the Solar System they can be found, and some details as to what they look like. Not every glow in the night sky is an aurora, though. An aurora is caused by particles from the Sun hitting the upper atmosphere and making the atoms and molecules there glow in different colors. Other phenomena cause other glows.

Apart from upper-atmosphere lightning phenomena such as sprites and elves, there is an exceptionally faint glow in the atmosphere all over the Earth that is called, not surprisingly, "airglow." While it happens around the same place in the atmosphere as the aurora, it is not caused by particles from the Sun; instead, it results from chemical reactions between the various components of the atmosphere at those altitudes.

Airglow is not to be confused with "skyglow," which is caused mostly by artificial lights such as street lights, billboards, and upward-pointing lights on the ground. The artificial light coming up from the ground reflects off particles in the atmosphere back down toward the ground, causing a glow in the sky that has nothing to do with nature. The artificial skyglow competes with, and usually dominates, all the natural glows and astronomical phenomena in the sky. (Teachers are invited to ask their students how many of them have seen the Milky Way.)

Farther out in the sky, there is a faint glow called the "zodiacal light." This is actually an astronomical phenomenon, caused by the Sun's light scattering off interplanetary dust that is more-or-less in the plane of the planetary orbits around the Sun.

GRADES 9-12 (CONTINUED)

Another faint glow in the sky that is caused by interplanetary dust is called "gegenschein," from the German word for "counter-glow," the increased brightness of light reflecting from a source that is directly behind the observer. One can see this brightening if one is riding on an airplane and looking out a window facing away from the Sun; the small patch on the ground surrounding the airplane's shadow is brighter than the rest of the ground. In the sky, the brightening is caused by light from the Sun reflecting off interplanetary dust that is in exactly the opposite direction from the Sun in the sky. The zodiacal light is caused by light generally reflecting off of the interplanetary dust; the gegenschein is caused specifically by light reflecting backwards toward the Sun and also the observer.

Another glow in the sky that resembles the aurora is a curious phenomenon called "Steve." This was discovered several years ago by amateur sky-watchers but has only recently been acknowledged by scientists. "Steve," which was named for a creature in the movie "Over the Hedge" ("Let's call it 'Steve,'" says a character in the film), is much rarer than an aurora and happens closer to the Equator than the aurora's oval. In addition, rather than being shaped like a curtain, it looks more like a ribbon of light in the upper atmosphere. With the study that Steve (now called "STEVE," for "Strong Thermal Emission Velocity Enhancement") is receiving, scientists have started figuring out what it is made of and what causes it. Contrary to some popular news headlines, it is not strictly an aurora. The new knowledge of Steve is an excellent example of amateurs and professionals working together to advance science. Here is the latest update (as of the time of writing) from Live Science.

Sixty Years Ago in the Space Race:

September 23, 1958: A Soviet "Luna" spacecraft was launched toward the Moon but catastrophic vibrations tore the rocket apart 93 seconds after liftoff.

September 26, 1958: The American Vanguard SLV3 was launched but did not reach orbit, re-entering over Central Africa.