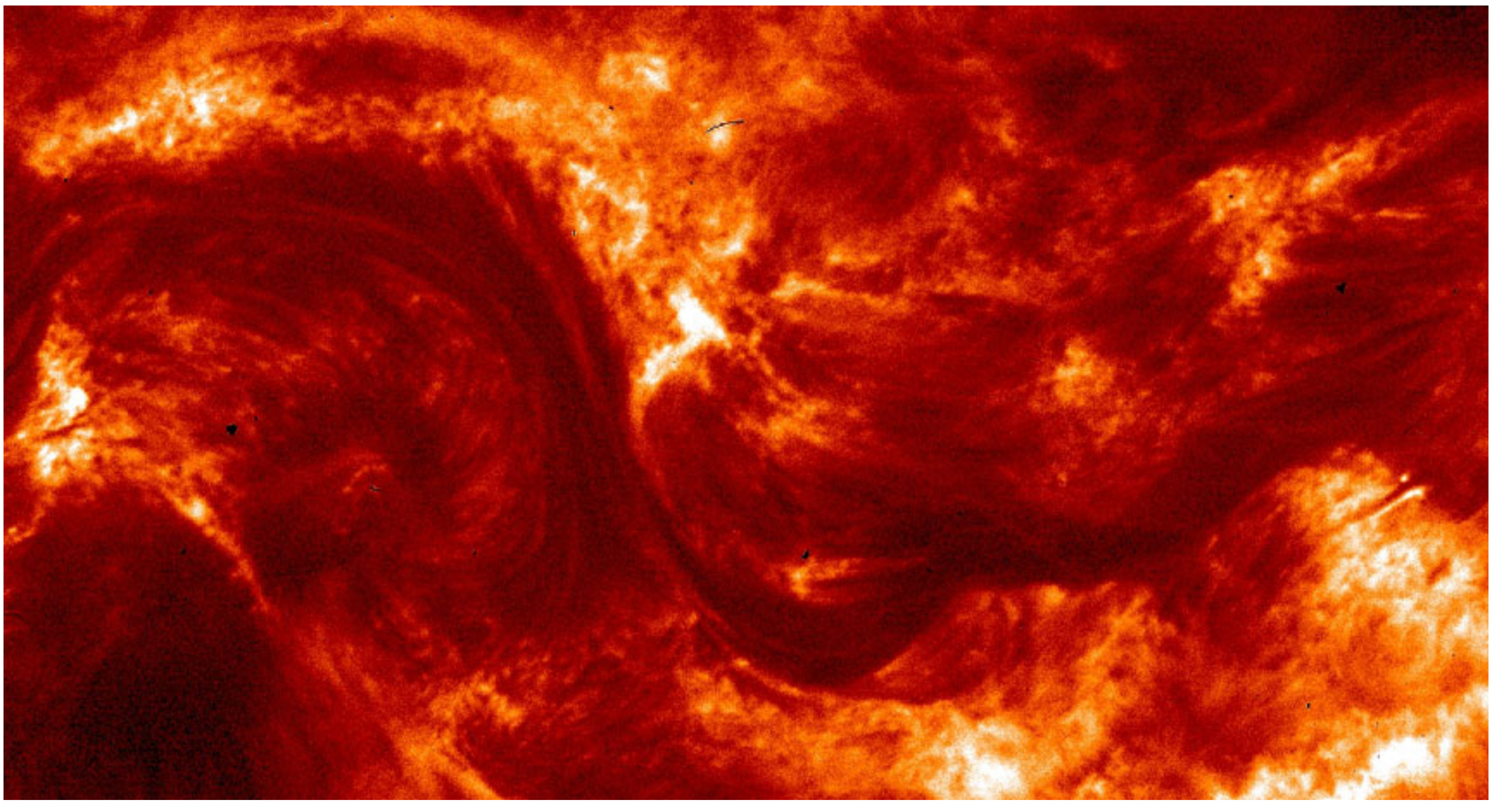
Science News for Students

ASTRONOMY SPACE PHYSICS

Cool Jobs: Solar sleuthing

These scientists are getting to know the sun, that mysterious star at the center of our solar system.

BY **ILIMA LOOMIS** JUN 16, 2016 — 7:15 AM EST

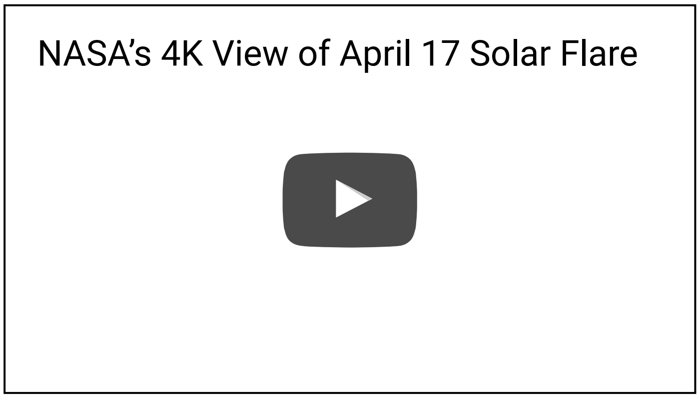


This is one of the most detailed images of the sun's corona, or thin outer surface, shown here in false color. The actual light was in the extreme ultraviolet part of the spectrum — a region not visible to the human eye. It was captured by a space telescope camera system, known as "Hi-C," launched in 2012.
Hi-C/NASA

This is one in a series on careers in science, technology, engineering and mathematics made possible with generous support from Alcoa Foundation.

In 1859, a massive burst of energy from the sun slammed into Earth. It caused telegraph wires to explode in sparks, which gave some telegraph operators electric shocks. People could see auroras — the *northern lights* — as far south as Cuba and Hawaii.

If such a powerful burst, called a *solar flare*, were to hit our planet today, it could disrupt modern civilization. The energy could zap satellites, fry computer systems and knock out power grids. So when can we expect the next "super flare" to strike?



FLARE OUT A mid-level solar flare, captured here by NASA's Solar Dynamics Observatory, on April 17, 2016. Seen on the sun's right side, it caused moderate radio blackouts on Earth. This video was recorded in extreme ultraviolet light (then color-coded to make it visible to human eyes). NASA Goddard Space Flight Ctr./SDO/Genna Duberstein

That's the question Steven Saar has been trying to answer. He is one of many scientists trying to better understand our sun.

Of all the bodies in the universe, the sun seems one of the most familiar. After all, by the time you turn 20, you'll have seen it rise and set some 7,300 times. But there's still a lot that science does not yet know about the star at the center of our solar system. What causes solar flares and can they be predicted? Why is the sun's atmosphere more than a million degrees hotter than its surface? How does the sun actually work?

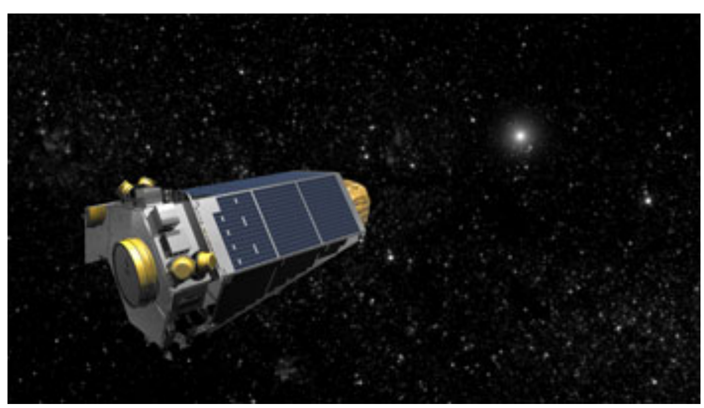
Our star is still full of mysteries. And here are three scientists who are working to crack the case.

Sampling other suns

Saar is an astronomer studying at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., who studies stars. He wanted to know how often the sun produces a super flare like the one in 1859. There was just one problem: it had only happened once in recorded history. That made it mathematically impossible to predict how often it might occur.

To get a larger sample, Saar had to look outside our solar system. "The sun is a star," he says. "So one can go out and try to find other stars that are as similar to the sun as possible."

Using data from NASA's *Kepler space telescope*, he looked for these "sun twins." He turned up 84 sun-like stars and observed them for around four years. He wanted to see how often they released bursts of energy at least as powerful as the 1859 flare. Then he combined all of these data to get an average.



Here, a depiction of the Kepler space telescope as it scouts for twins of our sun — and the planets that might orbit around them.

The stars he studied were younger and more active than our sun. That meant they had more flares. When he adjusted the results for an older, quieter star, he got his answer. A star like our sun should produce a super flare once every 200 to 480 years. His best guess: probably close to 350 years.

NASA

Saar was excited. “Getting an estimate for the sun itself, that was the holy grail, the key question,” he says.

Hooked on stars

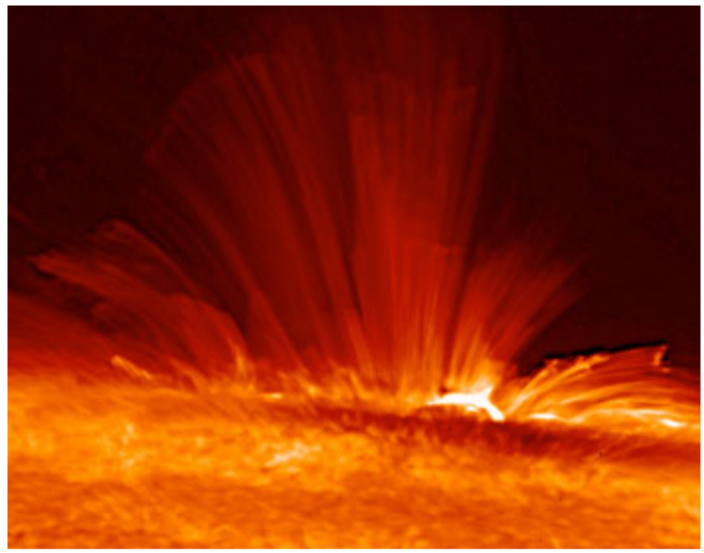
Saar has loved astronomy since he was a child. While he explored other sciences as a student, astronomy was always his favorite. Eventually he decided to become an astronomer. In *graduate school*, galaxies were a popular subject. Saar wanted to do something different. A mentor suggested he look at sun-like stars. And with that, he was hooked.

“The sun is obviously really important to us,” he says. “It’s actually an area of astronomy that has relevance for our daily life. So it’s interesting and important to understand how the sun works, how it can change over time and what it can do."

Saar saw that the key to understanding some of the sun’s biggest mysteries might actually be in looking at other stars.

“Although we can study the sun in great detail, it’s only a single example,” he says. “The idea is that if you study a lot of stars that are maybe similar to the sun, you might learn how the sun works.” In this case, it will be “indirectly, by looking at other examples."

Saar looks for stars that are similar to our sun in mass, temperature, age, chemical composition and other properties. Sometimes it’s useful to look at stars that are similar to the sun in every way but one. “What if the sun was a little bit heavier?” Saar asks. “What would that change? And what does it tell you about the sun itself?"



Super-hot, electrically charged gas (plasma) rises up in an arc from the surface of the Sun. These orange streamers reveal the structure of the sun’s magnetic field, seen here rising vertically from a sunspot.
Hinode, JAXA/NASA

Next, Saar would like to add more stars to his sample. That would let him predict the frequency of super flares more precisely. He also plans to look at his original data again. He wants to remove any other bursts of energy or activity near a star that may have been mistaken for a flare. That might lower the estimate slightly, getting it closer to results announced by Japanese scientists working on the same question. They had predicted a super flare once every 500 to 600 years. “I think we’re homing in on a good number,” Saar says.

A powerful new telescope

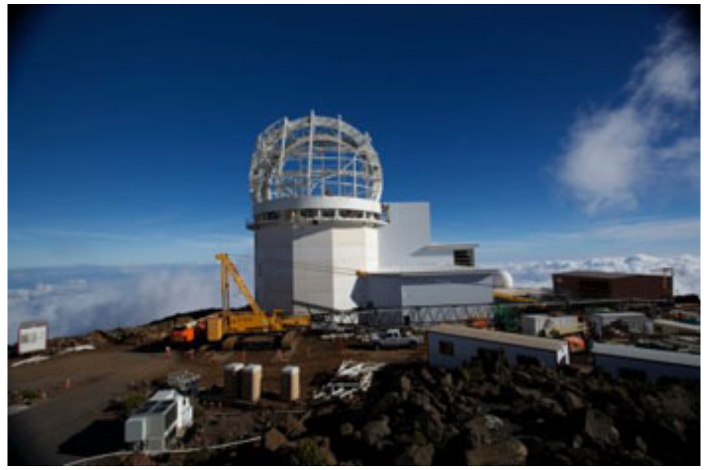
At the top of a 10,000-foot mountain on the Hawaiian island of Maui, the world’s most powerful solar telescope is under construction. When completed, the Daniel K. Inouye Solar Telescope will be able to see objects on the sun’s surface as small as 18 miles across.

Solar physicist Thomas Schad is helping design one of the five main tools that will be used in the telescope. He is a scientist with the University of Hawaii’s Institute for Astronomy in Pukalani. His instrument will analyze the makeup of the sun’s light.

Every element reflects light at a different *wavelength*. By splitting a beam of light into these wavelengths, scientists can learn about the sun's properties. These include such things as what chemicals it is made of and how hot they are.

This split light is referred to as a *spectrum*. Studying it doesn't just tell scientists about how the sun works. It also gives them a close-up look at some of the physics that might also be happening in more distant stars. Because the sun is so close, they can study it in much greater detail.

"We're looking at features you'll never see on another star," Schad explains.



Daniel K. Inouye Solar Telescope now under construction on Maui, Hawaii.
Brett Simison

Explainer: Understanding light and electromagnetic radiation (https://student.societyforscience.org/article/explainer-understanding-light-and-electromagnetic-radiation)

Schad got interested in solar physics while he was in college. He had taken part in a research program. The scientist who supervised him handed him data on the light *spectra* from explosions in the sun. Schad was asked to use those data to learn more about the explosions.

"It's amazing just how much information we can pull out from the sun by analyzing the spectrum," Schad now observes.

When what you need does not exist

As he began studying the sun, Schad realized that some of the tools he needed did not yet exist. He was excited to build them himself. "That's how science moves forward. You know what the questions are, and you come up with ways you might answer them." Plus, he adds, "I've always liked tinkering with things."

The instrument Schad is helping to build for the new solar telescope will analyze *infrared light*. It is called the Diffraction Limited Near Infrared Spectropolarimeter (SPEK-trow-po-ler-IM-eh-tur) — or DL-NISP, for short. Many of the most important elements in the sun reflect light at infrared wavelengths. When the telescope first sees light in 2019, the DL-NISP will be used to study magnetic fields at the sun's surface and in its lower atmosphere.

Schad must study the instrument's design and make sure it has all the parts that it will need to do its job. He sends guidelines to the people producing its lenses and mirrors. Then he orders other special parts. When all of the pieces are completed, he must test each one to make sure they meet the telescope's strict requirements. Then he will start putting them together.

In all, the telescope will have 21 lenses, 15 mirrors, three cameras and 21 motors. "We basically are building a big robot," he says.

Solving a solar mystery

If you took a stroll on the surface of the sun, the temperature would be a relatively cool 6,000° Celsius (11,000° Fahrenheit). But move up into the sun's atmosphere and it gets much toastier —

around 2 million degrees. Why is the sun's atmosphere so much hotter than its surface? And where does all that heat come from? These are among the biggest mysteries in solar science.

Some physicists think the heating of the solar atmosphere, or corona, is related to the sun's magnetism. They think that waves of magnetic energy vibrate. These waves might move energy from the sun's interior out into the corona, where it would be released as heat. But they're not sure exactly how that might work.

Data from the Hinode solar telescope, illustrated here, and another space-based telescope are helping scientists better understand the sun's magnetic fields and how they affect temperatures in the solar atmosphere.
NASA

Patrick Antolin wanted to test this theory. He is a solar physicist at the National Astronomical Observatory of Japan in Tokyo. He also is part of a team that worked with two space-based telescopes.

Japan's Hinode telescope observed how the sun's magnetic waves moved from side to side. NASA's IRIS telescope measured their twisting motion. Combining both sets of data gave the scientists a complete picture of the movement.

With this, they saw the first direct evidence that coronal heating is caused by *magnetic resonance*. That's when two magnetic waves vibrate in sync with one another, causing one of the waves to get stronger.

Antolin's team then used a supercomputer to run a numerical simulation. It showed how this movement created an unusual form of turbulence — a bumpy swirling of gases — not seen on Earth. It also showed how this turbulence released energy into the atmosphere.

Antolin was excited. And part of that was because this finding was such a surprise. When they started the project, his team didn't think it would work. True, his model predicted magnetic resonance would cause heating. But previous observations didn't seem to support the theory. Still, the physicist says: "I was unwilling to give up so easily."

When his group finally put all of the data together for the first time, these scientists were able to show how it worked. They realized magnetic resonance was not acting alone. It was accompanied by that strange turbulence. "The combination of both these mechanisms was producing exactly what was being observed," he says.

What's next for his research? Antolin's team only looked at magnetic resonance in solar prominences (large loops of gas). That's one type of structure in the sun. Next, they want to see if it also happens in another type of structure called spicules (little jets of gas).

If they can show that their model explains heating in many parts of the sun, it may someday solve the coronal mystery once and for all. And along with research by Saar and Schad, such findings will bring us a little closer to understanding our nearest star — our sun.

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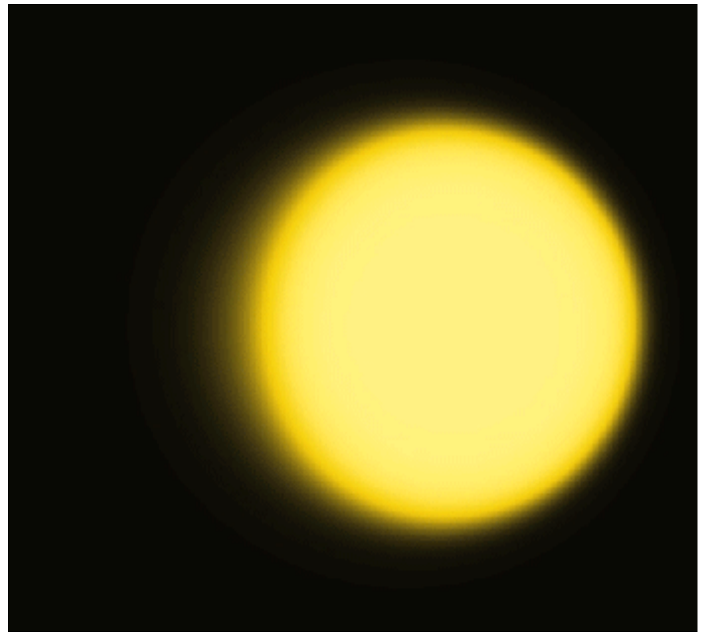

This animation shows the unusual turbulence created by magnetic waves in the sun. Patrick Antolin

astronomy The area of science that deals with celestial objects, space and the physical universe. People who work in this field are called **astronomers**.

astrophysics An area of astronomy that deals with understanding the physical nature of stars and other objects in space. People who work in this field are known as astrophysicists.

aurora A light display in the sky caused when incoming energetic particles from the sun collide with gas molecules in a planet's upper atmosphere. The best known of these is Earth's **aurora borealis**, or *northern lights.* On some outer gas planets, like Jupiter and Saturn, the combination of a fast rate of rotation and strong magnetic field leads to high electrical currents in the upper atmosphere, above the planets' poles. This, too, can cause auroral "light" shows in their upper atmosphere.

SOLAR SLEUTHING

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ASTRONOMER	KEPLER	SPLITTING
BURST	LENS	SYNC
CELSIUS	MAGNETIC	TELESCOPE
CHEMICAL	MAUI	TEMPERATURE
CORONA	PHYSICS	TINKERING
DESIGN	PLANET	TOASTIER
ENERGY	POWER GRID	TURBULENCE
EXPLOSION	POWERFUL	UNIVERSE
FLARE	PROMINENCE	WAVELENGTH
HINODE	ROBOT	
INFRARED	SOLAR	
IRIS	SPECTRA	

average (in science) A term for the arithmetic mean, which is the sum of a group of numbers that is then divided by the size of the group.

corona The envelope of the sun (and other stars). The sun's corona is normally visible only during a total solar eclipse, when it is seen as an irregularly shaped, pearly glow surrounding the darkened disk of the moon.

element (in chemistry) Each of more than one hundred substances for which the smallest unit of each is a single atom. Examples include hydrogen, oxygen, carbon, lithium and uranium.

galaxy A massive group of stars bound together by gravity. Galaxies, which each typically include between 10 million and 100 trillion stars, also include clouds of gas, dust and the remnants of exploded stars.

graduate school Programs at a university that offer advanced degrees, such as a Master's or PhD degree. It's called graduate school because it is started only after someone has already graduated from college (usually with a four-year degree).

infrared light A type of electromagnetic radiation invisible to the human eye. The name incorporates a Latin term and means "below red." Infrared light has wavelengths longer than those visible to humans. Other invisible wavelengths include X rays, radio waves and microwaves. It tends to record a heat signature of an object or environment.

Kepler Space Telescope A NASA mission to search for exoplanets — planets beyond the solar system — especially ones that might be Earth-like. The mission's development began in 2002, by placing the first orders for the needed instruments that would be used. The mission was named for Johannes Kepler (1571 to 1630), the first person to describe the motions of planets about the sun so that their positions could be predicted accurately. The spacecraft carrying the telescope Kepler spacecraft lifted off March 6, 2009, at 10:49 p.m. from the Cape Canaveral Air Force Station in Florida. As of May 20, it had turned up 2,327 confirmed exoplanets and another 4,696 possible ones.

lens (in physics) A transparent material that can either focus or spread out parallel rays of light as they pass through it. (in optics) A curved piece of transparent material (such as glass) that bends incoming light in such a way as to focus it at a particular point in space. Or something, such as gravity, that can mimic some of the light bending attributes of a physical lens.

magnetic field An area of influence created by certain materials, called magnets, or by the movement of electric charges.

magnetic resonance The vibration of two magnetic waves in synchrony, allowing one of them to strengthen.

mass A number that shows how much an object resists speeding up and slowing down — basically a measure of how much matter that object is made from.

mentor An individual who lends his or her experience to advise someone starting out in a field. In science, teachers or researchers often mentor students or younger scientists by helping them to refine their research questions. Mentors can also offer feedback on how young investigators prepare to conduct research or interpret their data.

model A simulation of a real-world event (usually using a computer) that has been developed to predict one or more likely outcomes.

National Aeronautics and Space Administration, or **NASA** Created in 1958, this U.S. agency has become a leader in space research and in stimulating public interest in space exploration. It was through NASA that the United States sent people into orbit and ultimately to the moon. It has also sent research craft to study planets and other celestial objects in our solar system.

numerical Having to do with numbers.

physics The scientific study of the nature and properties of matter and energy. Classical physics is an explanation of the nature and properties of matter and energy that relies on descriptions such as Newton's laws of motion. Quantum physics, a field of study which emerged later, is a more accurate way of explaining the motions and behavior of matter. A scientist who works in that field is known as a **physicist**.

simulate To deceive in some way by imitating the form or function of something. A simulated dietary fat, for instance, may deceive the mouth that it has tasted a real fat because it has the same feel on the tongue — without having any calories. A simulated sense of touch may fool the brain into thinking a finger has touched something even though a hand may no longer exists and has been replaced by a synthetic limb. (in computing) To try and imitate the conditions, functions or appearance of something. Computer programs that do this are referred to as **simulations**.

solar Having to do with the sun, including the light and energy it gives off.

solar prominence A cloud of solar material that become suspended above the star's surface by the sun's magnetic field. (This same magnetism also drives other events such as solar flares and the ejection of material from the sun's corona.) Prominences stream up and out along the sun's magnetic field lines before thinning and eventually breaking away from the sun's surface.

solar system The eight major planets and their moons in orbit around the sun, together with smaller bodies in the form of dwarf planets, asteroids, meteoroids and comets.

solar flare A burst of electromagnetic energy from the sun.

spectrum A range of related things that appear in some order. (in light and energy) The range of electromagnetic radiation types; they span from gamma rays to X rays, ultraviolet light, visible light, infrared energy, microwaves and radio waves.

spicule A small and usually slender, sharp-pointed crystal or part of some object. (in astronomy) A dense jet of gas that erupts from the lowest levels of the sun's atmosphere. They can rise some 10,000 kilometers (roughly 6,000 miles) above the sun's surface before falling back to it again. Perhaps 100,000 of them across the solar surface may be active at any given time.

star Thebasic building block from which galaxies are made. Stars develop when gravity compacts clouds of gas. When they become dense enough to sustain nuclear-fusion reactions, stars will emit light and sometimes other forms of electromagnetic radiation. The sun is our closest star.

telescope Usually a light-collecting instrument that makes distant objects appear nearer through the use of lenses or a combination of curved mirrors and lenses. Some, however, collect radio emissions (energy from a different portion of the electromagnetic spectrum) through a network of antennas.

turbulence The chaotic, swirling flow of air. Airplanes that run into turbulence high above ground can give passengers a bumpy ride.

universe The entire cosmos: All things that exist throughout space and time. It has been expanding since its formation during an event known as the Big Bang, some 13.8 billion years ago (give or take a few hundred million years).

wavelength The distance between one peak and the next in a series of waves, or the distance between one trough and the next. Visible light — which, like all electromagnetic radiation, travels in waves — includes wavelengths between about 380 nanometers (violet) and about 740 nanometers (red). Radiation with wavelengths shorter than visible light includes gamma rays, X-rays and ultraviolet light. Longer-wavelength radiation includes infrared light, microwaves and radio waves.

Readability Score:

6.5

NGSS:

- MS-ETS1-4
- HS-ESS1-1
- HS-ESS1-3

Further Reading

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