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What is Space?

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By [Elizabeth Howell](#) | Contributions from [Chelsea Gohd](#) published February 18, 2022

Space, the final frontier, what is it?



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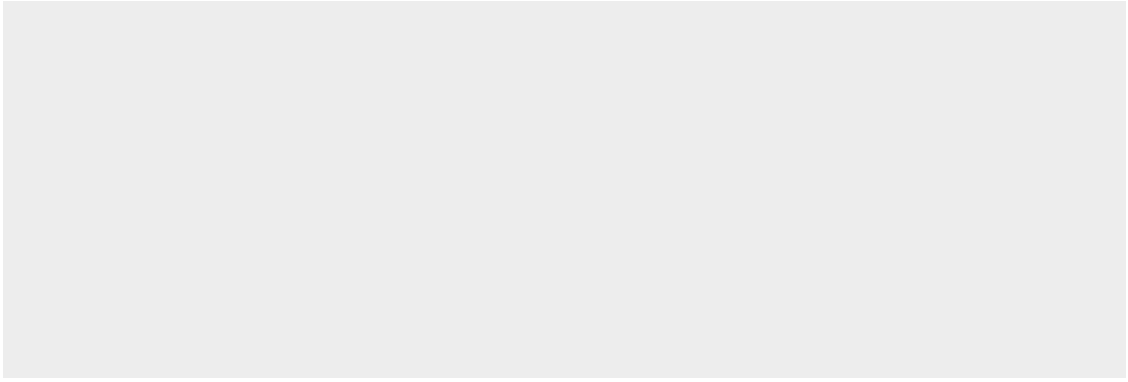


What is space? In this image you can see the planetary nebula NGC 6891 glows in this Hubble Space Telescope image. (Image credit: NASA, ESA, A. Hajian (University of Waterloo), H. Bond (Pennsylvania State University), and B. Balick (University of Washington); Processing: Gladys Kober (NASA/Catholic University of America))

[Jump to: Invisible radiation](#) | [Dark matter and energy](#) | [Black holes](#) | [Stars, planets, asteroids and comets](#) | [Galaxies and quasars](#)

We often refer to our expanding universe with one simple word: space. But where does space begin and, more importantly, what is it?

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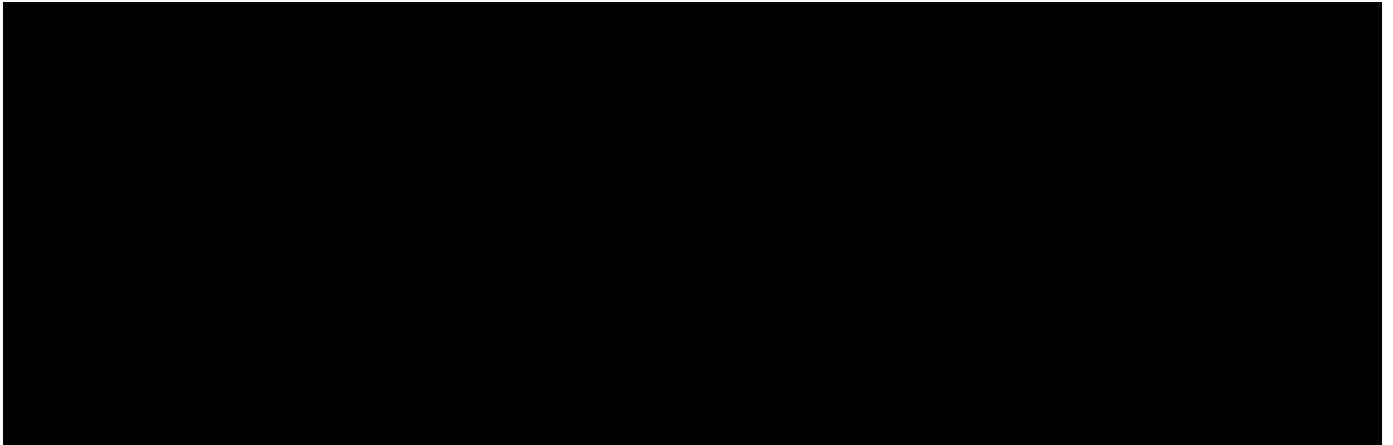
Space is an almost perfect vacuum, nearly void of matter and with extremely low pressure. In space, sound doesn't carry because there aren't molecules close enough together to transmit sound between them. Not quite empty, bits of gas, dust and other matter floats around "emptier" areas of the universe, while more crowded regions can host planets, [stars](#) and galaxies.


From our [Earth](#)-bound perspective, outer space is most often thought to begin about 62 miles (100 kilometers) above sea level at what is known as the [Kármán line](#). This is an imaginary boundary at an altitude where there is no appreciable air to breathe or scatter light. Passing this altitude, blue starts to give way to black because oxygen molecules are not in enough abundance to make the sky blue.

Related: [Where DOES Space Begin? Virgin Galactic Flies Right into the Debate](#)

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No one knows exactly how big space is. It's difficult to determine because of what we can see in our detectors. We measure long distances in space in "light-years," representing the distance it takes for light to travel in a year (roughly 5.8 trillion miles (9.3 trillion kilometers)).

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From the light that is visible in our telescopes, we have charted galaxies reaching almost as far back as the Big Bang, which is thought to have started our universe about 13.8 billion years ago. This means we can "see" into space at a distance of almost 13.8 billion light-years. But the universe continues to expand, making "measuring space," even more challenging.

Additionally, astronomers are [not totally sure if our universe is the only one that exists](#). This means that space could be a whole lot bigger than we even think.

SPACE RADIATION INVISIBLE TO HUMAN EYES

The majority of space is relatively empty, with just stray bits of dust and gas floating around. This means that when humans send a probe to a distant planet or asteroid, the craft will not encounter "drag" in the same way that an airplane does as it sails through space.

In fact, the vacuum environment in space and on the moon, is one reason why the lunar lander of the Apollo program was designed to have an almost [spider-like appearance](#), as it was described by the Apollo 9 crew. Because the spacecraft was designed to work in a zone with no atmosphere, it didn't need to have smooth edges or an aerodynamic shape.

In addition to the bits of debris that speckle the "emptier" regions of space, research has shown that these areas are also home to different forms of radiation. In our own solar system, the [solar wind](#) — charged particles that stream from the sun — emanate throughout the solar system and occasionally cause auroras near Earth's poles. [Cosmic rays](#) also fly through our neighborhood, stemming from supernovas outside of the solar system.

In fact, the universe as a whole is inundated with what is known as the cosmic microwave background (CMB), which is essentially the leftover radiation from the explosion mostly commonly known as the Big Bang. The CMB is the oldest radiation that our instruments can detect.

Infographic: [Cosmic Microwave Background Explained](#)



There remain two giant mysteries about space: [dark matter](#) and [dark energy](#).

While scientists have provided extensive evidence for the existence of dark matter and dark energy, they are each still poorly understood as, so far, scientists cannot directly observe them and can only observe their effects.

Roughly 80% of all of the mass in the universe is made up of what scientists have dubbed "dark matter," but it's not known what it actually is or if it is even matter by our current definition. However, while dark matter doesn't emit light or energy and cannot, therefore, be directly observed, scientists have found overwhelming evidence that it makes up the vast majority of the matter in the cosmos.

Dark energy might have a similar name to dark matter, but it's a whole different component entirely.

Thought to make up nearly 75% of the universe, dark energy is a mysterious and unknown force or entity that scientists think is responsible for the universe's ongoing expansion.



Matter swirling into the supermassive black hole at the centre of M87. (Image credit: Event Horizon Telescope)

Smaller [black holes](#) can form from the gravitational collapse of a gigantic star, which forms a singularity from which nothing can escape — not even light, hence the name of the object. No one is quite sure what lies within a black hole, or what would happen to a person or object who fell into it – but research is ongoing.

An example is gravitational waves, or ripples in space-time that come from interactions between black holes. This was first predicted by Albert Einstein at the turn of the last century, when he showed that time and space are linked; time speeds up or slows down when space is distorted.

As of mid-2017, the Laser Interferometer Gravitational-Wave Observatory (LIGO) Scientific Collaboration has announced three [black-hole interactions and mergers](#) detected through gravitational waves, in just two years.

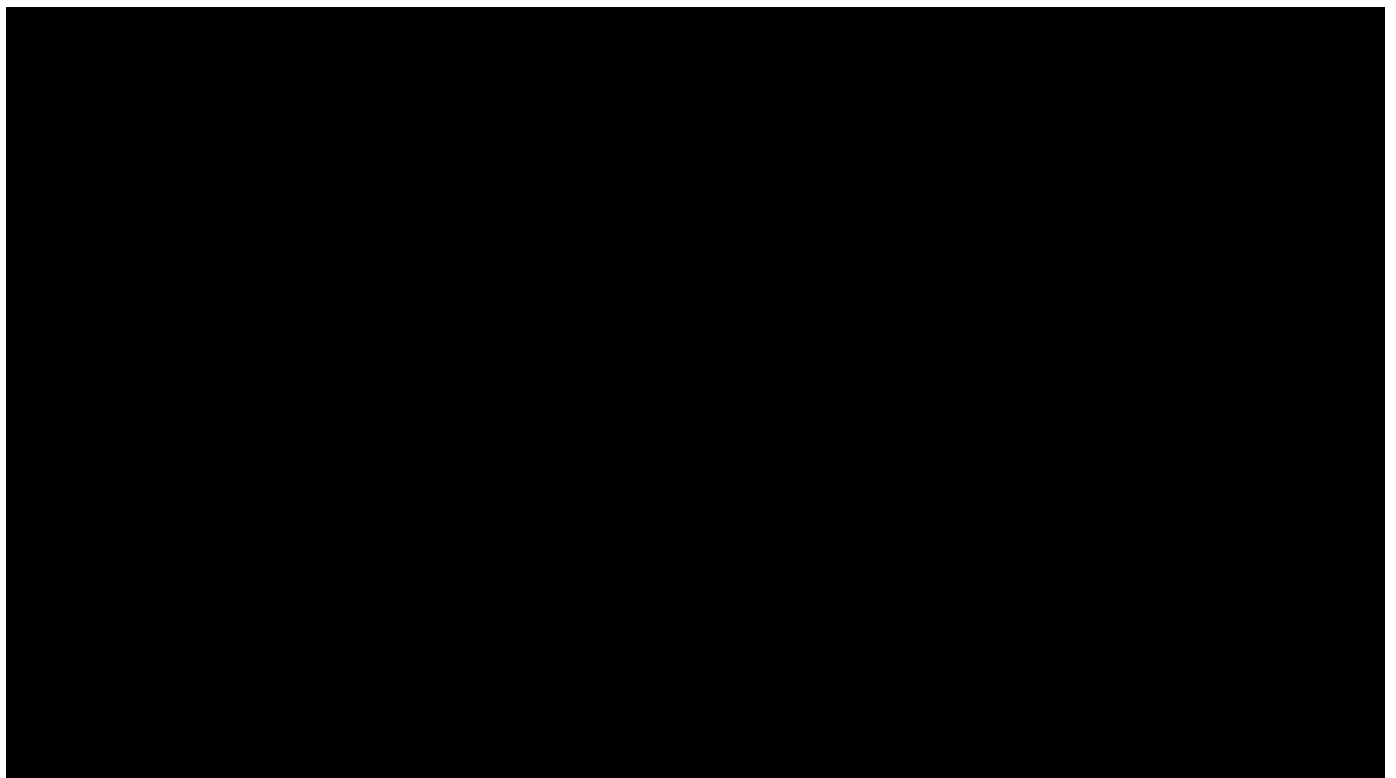
The team found these three events in about two years, indicating that when LIGO is implemented at full sensitivity, the observatory may be able to find these sorts of events frequently, scientists said in May 2017. Should a bunch of these black hole events be detected, it could help scientists learn how black holes of a certain size (several tens of sun masses) are born, and later merge into new black holes.



The exoplanet wasp-103b and its star. (Image credit: ESA)

[Stars](#) (like our own sun) are immense balls of gas that produce their own radiation. They can range from red supergiants to cooling white dwarfs that are the leftovers of supernovas, or star explosions that occur when a big one runs out of gas to burn. These explosions spread elements throughout the universe and are the reason that elements such as iron exist. Star explosions can also give rise to incredibly dense objects called [neutron stars](#). If these neutron stars send out pulses of radiation, they are called pulsar stars.

Planets are objects whose definition came under scrutiny in 2006, when astronomers were debating [whether Pluto could be considered a planet or not](#). At the time, the International Astronomical Union (the governing body on Earth for these decisions) ruled that a planet is a celestial body that orbits the sun, is massive enough to have a nearly round shape, and has cleared its orbit of debris. Under this designation, Pluto and similar small objects are considered "dwarf planets," although not everyone agrees with the designation. After the New Horizons spacecraft flew by Pluto in 2015, principal investigator Alan Stern and others again opened up the debate, saying the diversity of terrain on Pluto makes it more like a planet.



The definition of extrasolar planets, or planets outside the solar system, is still not firmed up by the IAU, but essentially astronomers understand it to mean objects that behave like planets in our neighborhood. The first such planet was found in 1992 (in the [constellation Pegasus](#)) and since that time, thousands of alien planets have been confirmed — with many more suspected. In solar systems that have planets under formation, these objects are often called "protoplanets" because they aren't quite the maturity of those planets we have in our own solar system.

[Asteroids](#) are rocks that are not quite big enough to be dwarf planets. We've even found asteroids with rings around

them, such as 10199 Charilko. Their small size often leads to the conclusion that they were remnants from when the solar system was formed. Most asteroids are concentrated in a belt between the planets Mars and Jupiter, but there are also many asteroids that follow behind or ahead of planets, or can even cross in a planet's path. NASA and several other entities have asteroid-searching programs in place to scan for potentially dangerous objects in the sky and monitor their orbits closely.

In our solar system, [comets](#) (sometimes called dirty snowballs) are objects believed to originate from a vast collection of icy bodies called the Oort Cloud. As a comet approaches the sun, the heat of our star causes ices to melt and stream away from the comet. The ancients often associated comets with destruction or some sort of immense change on Earth, but the discovery of [Halley's Comet](#) and related "periodic" or returning comets showed that they were ordinary solar system phenomena.

GALAXIES AND QUASARS



An artist's rendering of the double quasar, located in two merging galaxies about 10 billion light-years away (Image credit: NASA, ESA, and J. Olmsted (STScI))

Among the biggest cosmic structures we can see are galaxies, which essentially are vast collections of stars. Our own galaxy is called the [Milky Way](#), and is considered a "barred spiral" shape. There are several types of galaxies, ranging from spiral to elliptical to irregular, and they can change as they come close to other objects or as stars within them age.

Often galaxies have [supermassive black holes](#) embedded in the center of their galaxies, which are only visible through the radiation that each black hole emanates as well as through its gravitational interactions with other objects. If the black hole is particularly active, with a lot of material falling into it, it produces immense amounts of radiation. This kind of a galactic object is called a [quasar](#) (just one of several types of similar objects.)

Large groups of [galaxies can form in clusters](#) that are groups as large as hundreds or thousands of galaxies bound together gravitationally. Scientists consider these the largest structures in the universe.

This page was updated in Jan. 2022 by Space.com senior writer Chelsea Gohd.

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Elizabeth Howell



Staff Writer, Spaceflight

Elizabeth Howell (she/her), Ph.D., is a staff writer in the spaceflight channel since 2022 covering diversity, education and gaming as well. She was contributing writer for [Space.com](#) for 10 years before joining full-time. Elizabeth's reporting includes multiple exclusives with the White House and Office of the Vice-President of the United States, an exclusive conversation with aspiring space tourist (and NSYNC bassist) Lance Bass, speaking several times with the International Space Station, witnessing five human spaceflight launches on two continents, flying parabolic, working inside a spacesuit, and participating in a simulated Mars mission. Her latest book, "[Why Am I Taller?](#)", is co-written with astronaut Dave Williams. Elizabeth holds a Ph.D. and M.Sc. in Space Studies from the University of North Dakota, a Bachelor of Journalism from Canada's Carleton University and a Bachelor of History from Canada's Athabasca University. Elizabeth is also a post-secondary instructor in communications and science at several institutions since 2015; her experience includes developing and teaching an astronomy course at Canada's Algonquin College (with Indigenous content as well) to more than 1,000 students since 2020. Elizabeth first got interested in space after watching the movie Apollo 13 in 1996, and still wants to be an astronaut someday. Mastodon: <https://qoto.org/@howellspace>

With contributions from

[Chelsea Gohd](#) Senior Writer

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Fall into a black hole in mind-bending NASA animation (video)

Black hole week is on, and to celebrate NASA is taking us on a way to plunge past the event horizon of a supermassive black hole and on a time-bending trip around the same cosmic titan.

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China's space plane releases another mystery object into orbit

China's experimental spaceplane released an unknown object into Earth's orbit on May 24, which could be a subsatellite deployment or an indication the spacecraft is nearing the end of its third mission.

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"채소값"오르자, 연봉도 올랐다... "이 자격증 따라!!"

이상기후로 농산물 공급이 원활하지 않아 "손해평가사" 자격증 수요 급증... 1,000만 원씩 번다는 손해평가사 자격증 인기... 선착순 30명 한정 자격증 취득 시 수강료 전액면제, 상담 신청만해도 "합격필수자료" 무료증정.

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Not-so-static fire: Private Chinese rocket accidentally launches during test

Space Pioneer's new Tianlong-3 rocket took to the skies accidentally on Sunday (June 30), then crashed back to Earth in a dramatic explosion.

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Watch SpaceX's Starship Super Heavy booster splash down in this epic video

The huge first stage of SpaceX's Starship megarocket came back to Earth as planned during the vehicle's June 6 test flight, and cameras recorded the dramatic action.

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What became of the flags Apollo astronauts left on the moon?

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Japanese billionaire cancels private flight around the moon on SpaceX's giant Starship

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NASA confirms space debris in North Carolina was from SpaceX Crew Dragon reentry

NASA has confirmed that pieces of debris found throughout the mountains of North Carolina are the remnants of SpaceX Crew Dragon hardware that reentered the atmosphere in May 2024.

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Earth will get another moon this month — but not for long!

Earth will get itself another moon this month, but only briefly. The "mini-moon" in the form of asteroid 2024 PT5 will stick around for just two months.

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Co-Founder of Google Brain, Andrew Ng, Recommends: 5 Books For Turning Your Life Around

Andrew Ng, computer scientist and technology entrepreneur focusing on artificial intelligence, shares the five books he thinks will change your life.

Blinkist: Andrew Ng's Reading List | Sponsored

Watch SpaceX Falcon 9 rocket generate sonic boom during landing (video)

A SpaceX video shows a Falcon 9 first stage's post-launch return to Earth in great detail, even capturing the sonic boom generated during the descent.

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Watch SpaceX Crew-8 astronauts return to Earth early Oct. 25

The astronauts of SpaceX's Crew-8 mission will return to Earth early Friday morning (Oct. 25), and you can watch their homecoming live.

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성장기에 "이것"알고 187cm까지 쑥~ 뭉길래??

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Fall back to Earth with Falcon 9 payload fairings in stunning new SpaceX video

A recent SpaceX Starlink launch featured an extra video treat: a view of the Internet satellites being revealed for future Internet service. But Starlink's effects on astronomy still causes concern.

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Before plunging to its death, NASA's Cassini spacecraft saw secrets in the seas of Saturn's moon Titan

Seven years ago, the Cassini mission ended when the spacecraft dramatically crashed into Saturn, but the data it collected is still delivering results, revealing the secrets of Titan's oceans.

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SpaceX's Starship won't be licensed to fly again until late November, FAA says

SpaceX's Starship likely won't be able to fly again until late November at the earliest, because the FAA and partner agencies need more time for licensing reviews.

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