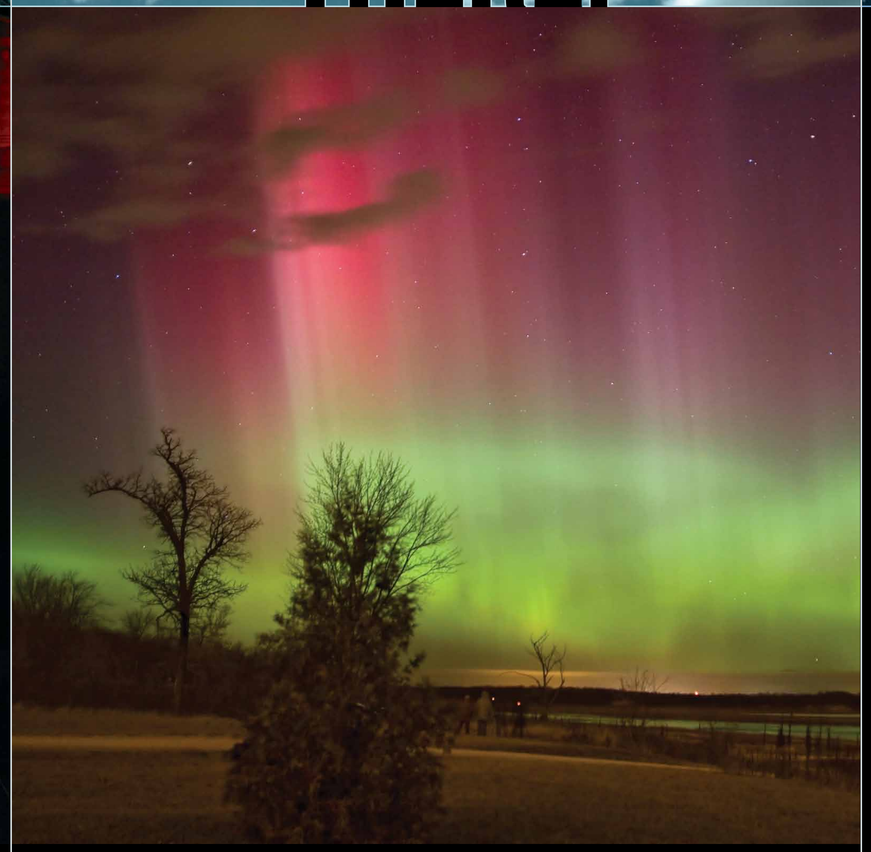
HERE.

THERE.

EVERYWHERE.

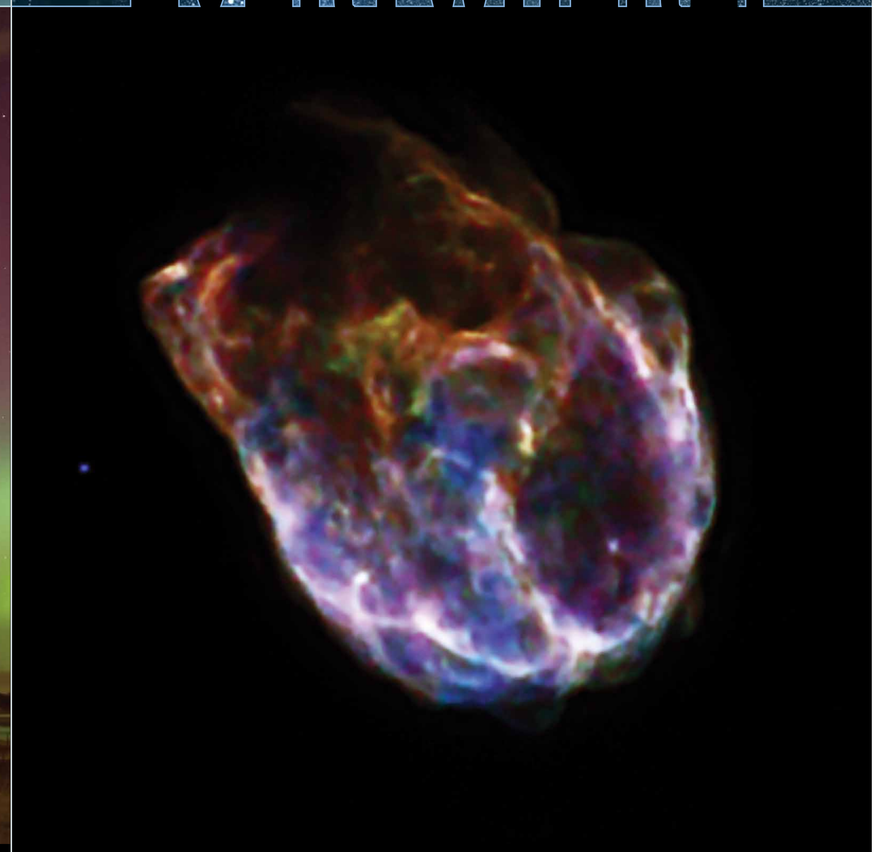
Neon Sign.

In a neon sign, an electric current runs through a tubular glass fixture that is filled with gas. This electric current causes collisions between the electrons and atoms in the neon gas. When various electrons relax, the energy released produces light that has a very specific color that invite us through the diner door.



Aurora.

Streams of particles with electric charge are continually leaving the Sun and traveling through the Solar System. As these particles approach the Earth, some of them are channeled by the planet's magnetic field toward the North and South poles where they collide with atoms in the Earth's atmosphere. This produces the famous light shows we call auroras, or, more commonly in the Northern Hemisphere, the "Northern Lights."



Supernova Remnant.

When a massive star explodes, it generates an outgoing blast wave that travels through the space around the now-dead star. This wave heats the gas in this region to a temperature of several million degrees, making the molecules and atoms in the gas vibrate and collide. When the electrons in this superheated gas relax, they release their excess energy mostly in the form of X-ray light.

ATOMIC LIGHT SHOW Atoms, the building blocks of matter, are constantly in motion, moving around at speeds that are thousands of miles per hour at room temperatures, and millions of miles per hour behind a supernova shock wave. In a collision of an atom with another atom, or with a free-roaming electron, energy can be transferred to the atom. This extra energy can then be released in the form of a light wave.

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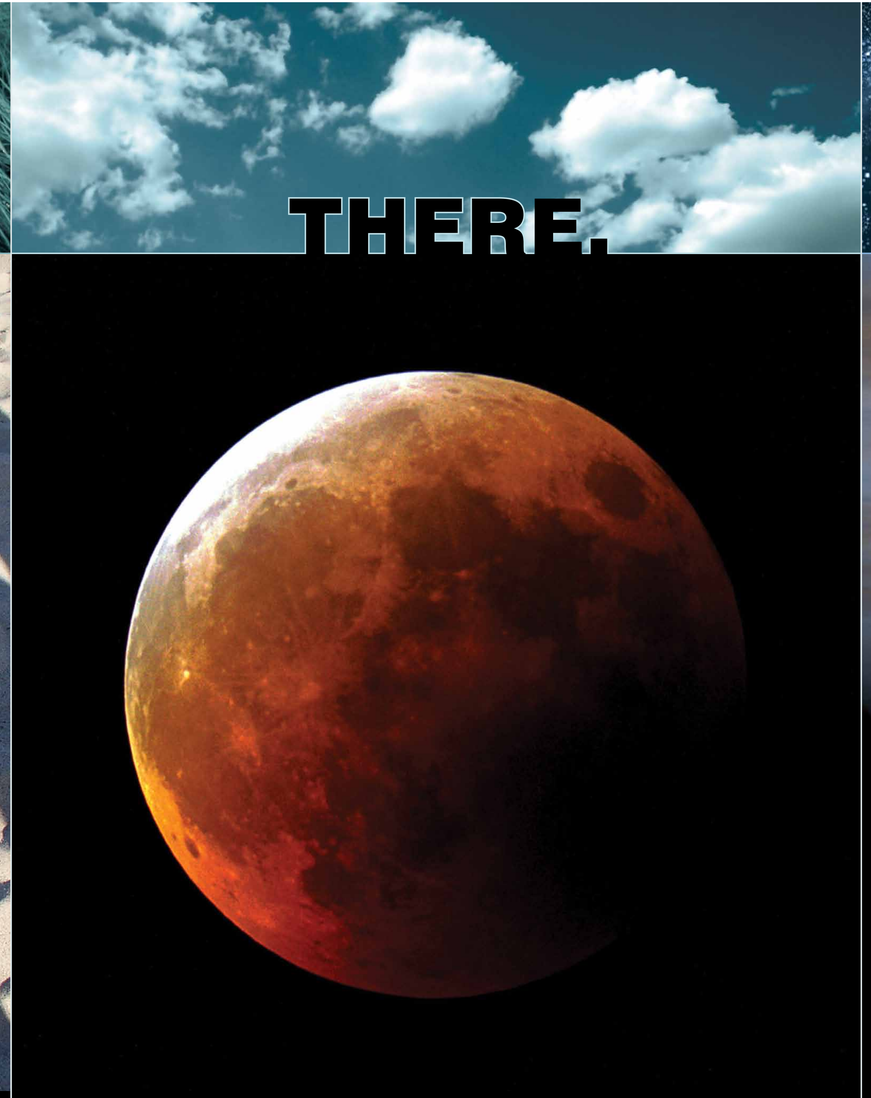

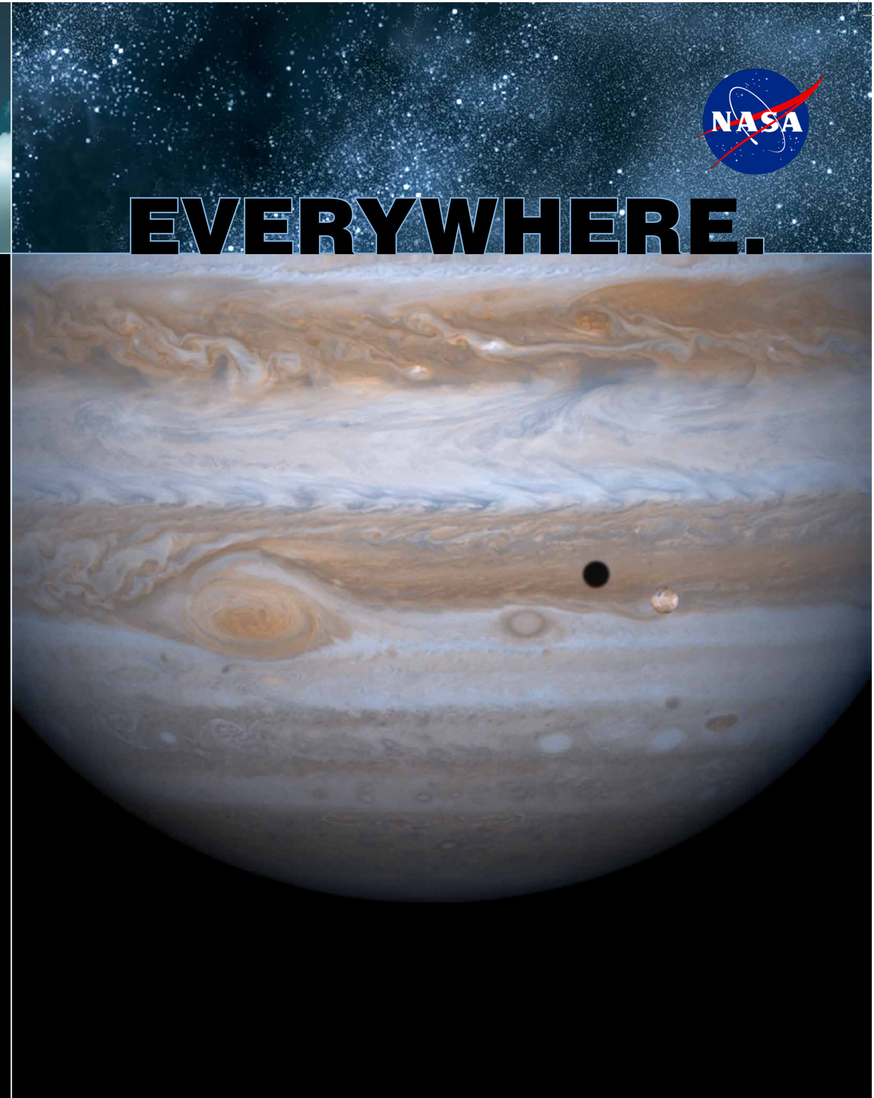

People in Shadow.

When a light source is blocked, a shadow results. Here we see the familiar shadows from people on a beach whose bodies are blocking the light of the Sun from reaching the sand behind them.

Lunar Eclipse.

The light we see from the Moon is produced by reflected light from the Sun. During a "lunar eclipse," the alignment of the Sun, Earth, and Moon causes the Earth to block the light from the Sun and cast a shadow over the Moon. Some light is bent by the Earth's atmosphere and does reach the lunar disk, producing the faint red glow.

A Moon of Jupiter.

Shadows occur on other planets as well. In this image, sunlight shining onto Jupiter is blocked by one of its moons as it passes over the face of the planet. A similar type of event takes place on Earth during a solar eclipse, when the Moon blocks the Sun's light and casts a shadow onto some portions of the Earth.

LIGHT THAT DOES NOT PASS You are relaxing with a book on a nice sunny day when a friend leans over your shoulder and the page goes dark. "Hey, you're blocking my light!" It is a familiar experience. Any time an object blocks the light from another source, it forms a shadow.

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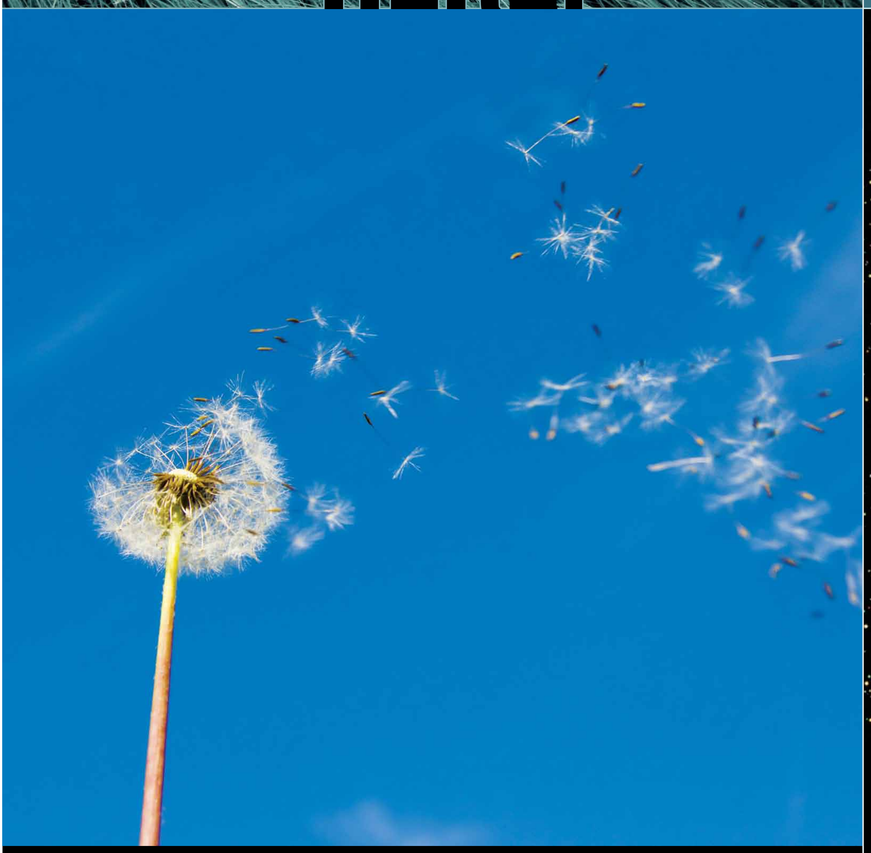
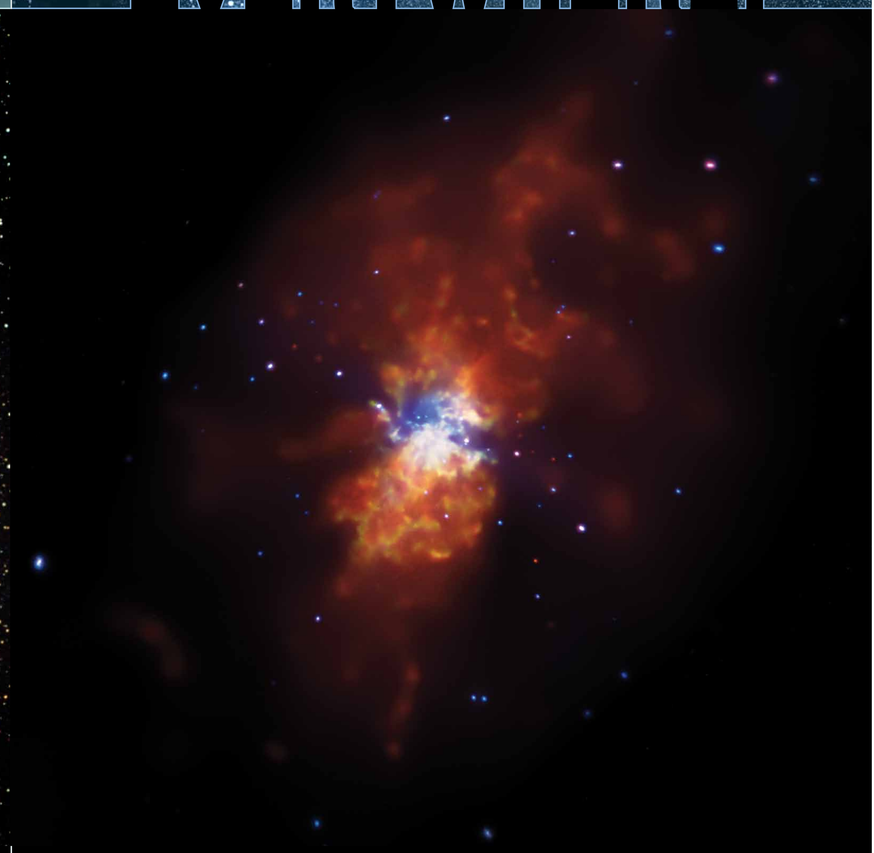


Dandelion.

Feeling the wind blow and seeing its effects is a very common occurrence on Earth. Here, the seeds of a dandelion are distributed over a field by a gentle breeze. If particles are light enough, winds can suspend them and even scatter them aloft as dust or haze, like smog, or the dust spread over long distances in the atmosphere after volcanic eruptions.

Comet Tail.

There is a stream of charged particles flowing off the Sun known as the solar wind. Comets have two tails: one that is mainly dust, and another that is composed of charged particles called ions. Scientists have found that the ion tail is always pointing directly away from the Sun, no matter which way the comet itself is going. This is because the solar wind forces the ion tail to point in the direction where the solar wind is heading. The dust tail is composed of heavier particles that are less affected by the solar wind, and generally points away from the motion of the comet.



Galactic Winds.

When galaxies experience bursts of star formation, the most massive of the stars race through their evolution and explode as supernovas. If the rate of supernovas is high enough, the combined effects of many supernova shock waves drives a galactic-scale wind that blows gas out of the galaxy. These superwinds were likely the main way that carbon, nitrogen, oxygen, iron and other heavy elements formed in supernovas were spread throughout the Universe.

WHERE THE WIND BLOWS Winds can move particles from one place to another. On Earth, winds can blow briefly during a storm, and over long time scales, as in the jet stream. Winds have also been detected on other planets, in the space between stars, and in galaxies.

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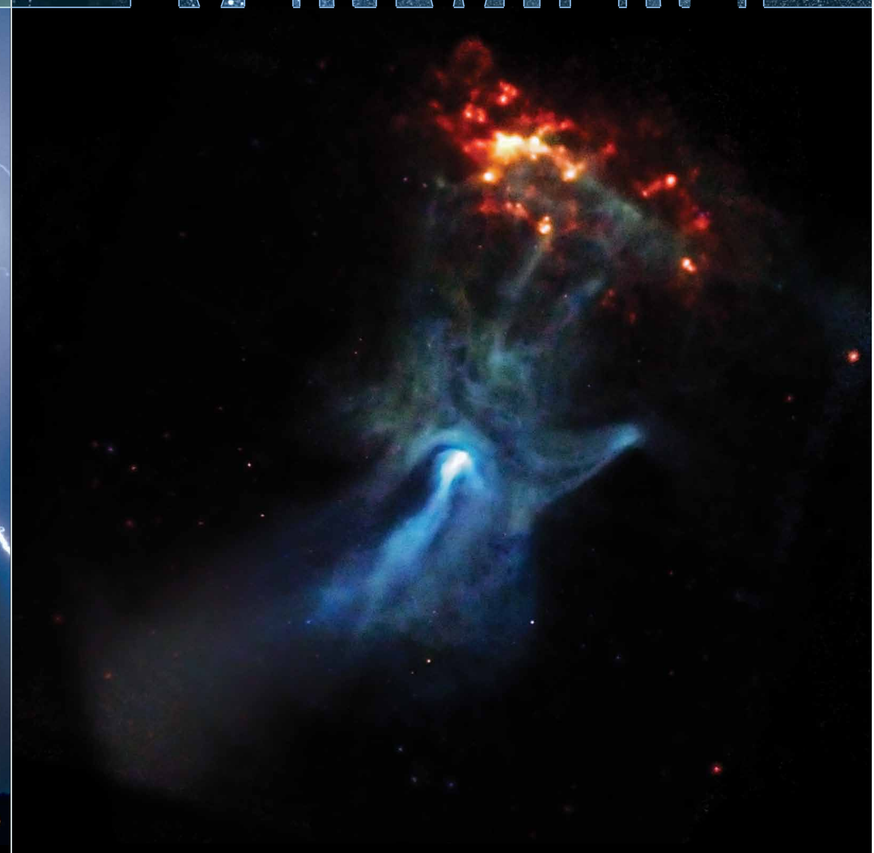
Arc Welder.

Because of the large electric voltage between the welder's tool and the metal, sparks fly and a strong electric current flows, generating a brilliant light display and enough heat to melt the metal and allow it to bond to another metallic surface.

Lightning.

In massive storm clouds, the friction between large particles composed of many atoms builds up a large separation of electric charge, and creates voltages approaching 100 million volts. When the voltage becomes this large, it can cause an explosive electric discharge observed as a lightning bolt.



Spinning Stars.

An electric voltage can also be produced by the rotation of a magnet in the presence of an electrical circuit. This is the principle behind a generator. Rapidly spinning, highly magnetic neutron stars can act as generators and produce electric voltages in excess of a trillion volts. The energy released by these cosmic super-generators can light up clouds that extend over several light years.

ZAP! You shuffle along a carpet, reach out to touch a doorknob and—zap!—a sudden flow of current, or electric discharge, gives you a mild shock. The cause? Friction between your feet and the carpet built up negative electric charge on your body. Electric discharges can occur wherever there is a large build-up of electric charge, and can create spectacular displays of sudden energy release on Earth and in space.

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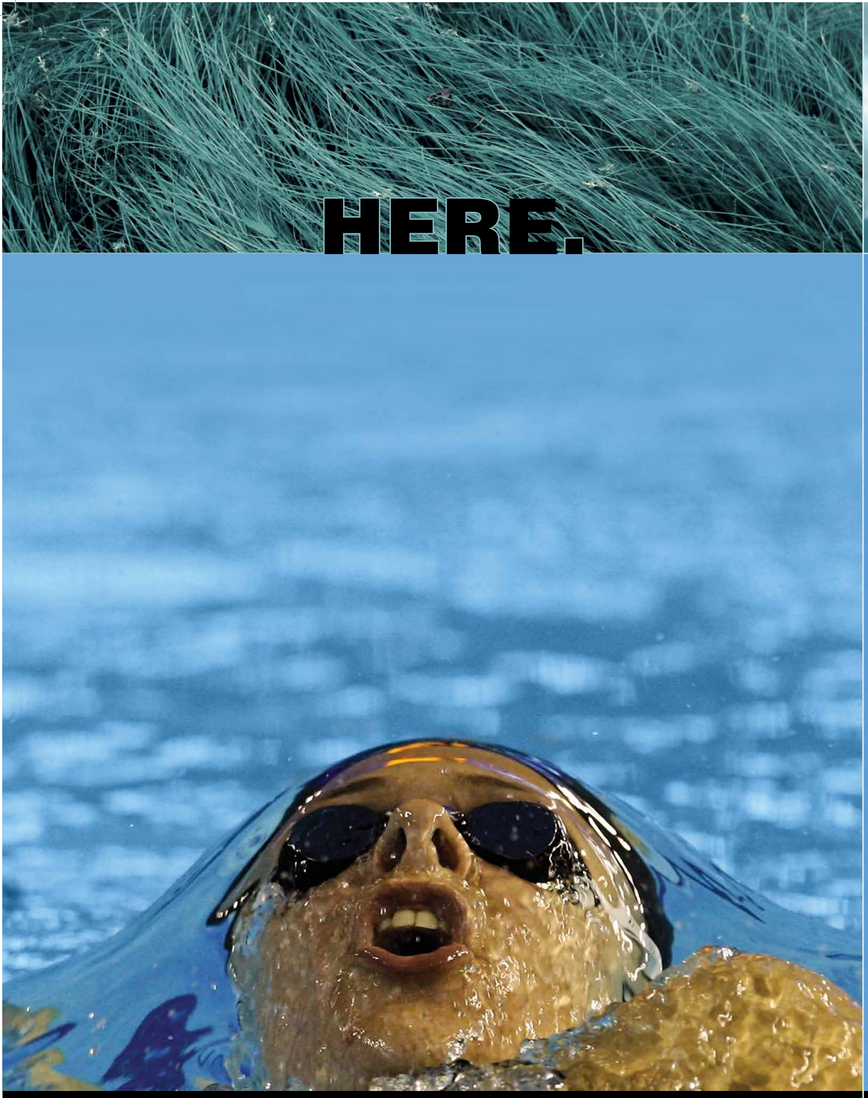

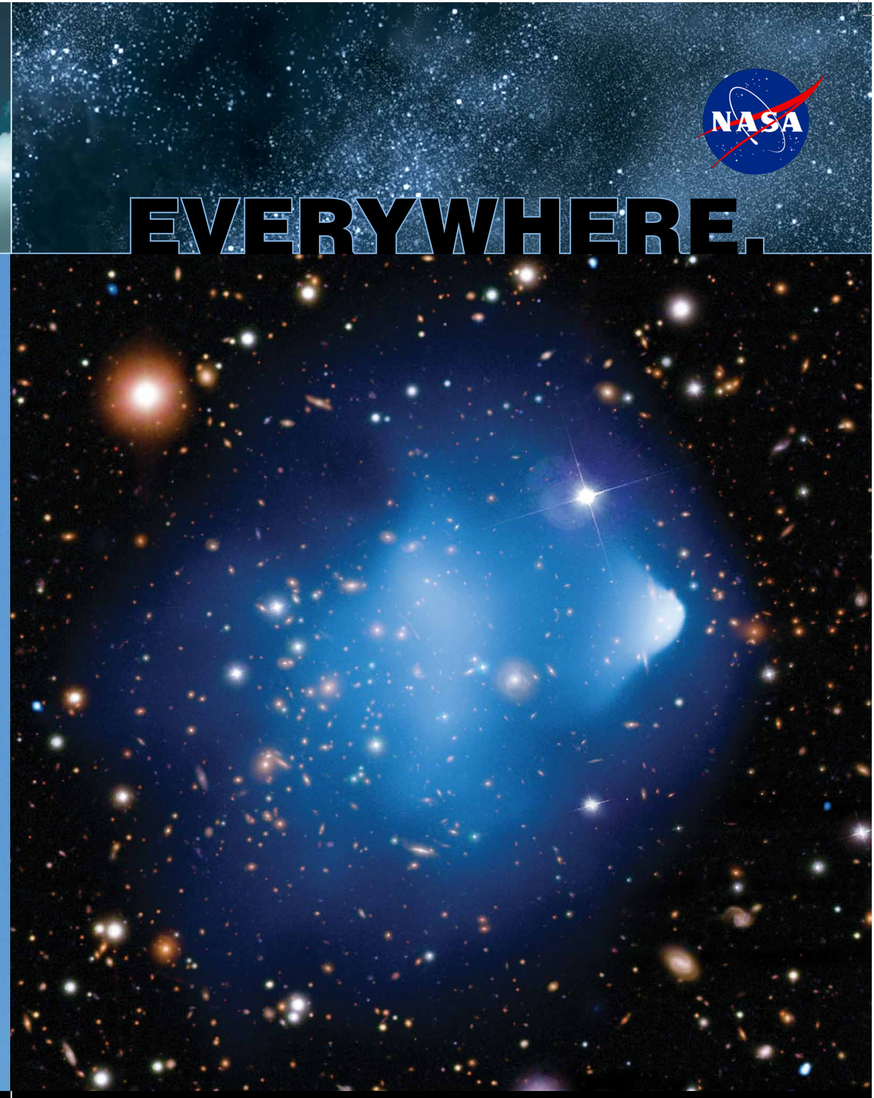

Swimmer.

As this swimmer powers through the pool, each motion in her direction of progress pushes on the water. However, she is swimming faster than the waves can move away. The result is the build up of a bow wave in the direction of her motion. If this wave were seen from above, it would have the shape of a "V."

Supersonic Jet.

As an airplane moves through the air, it pushes on the air in front of it, creating sound waves. If the airplane is moving faster than the speed of sound, a bow shock is created. When this shock wave passes by our position on the ground, all of the sound waves that would have normally propagated ahead of the plane are combined together so at first we hear nothing, and then we hear the boom created by the accumulated sound waves.

Merger of Galaxy Clusters.

Galaxies are often found in large groups, called clusters, which are held together by gravity. The galaxies in clusters are immersed in huge clouds of multimillion-degree gas. Here two clusters are merging together, with one cloud of gas plowing through a larger one at a supersonic speed. This creates sound waves that merge into a bow shock. The cone of increased pressure produced by the bow shock makes it detectable by an X-ray telescope.

THE SHAPE OF SPEED As a duck paddles across a pond, it creates ripples or waves that move out in front of it. If the duck paddles fast enough, the ripples will merge into a cone-shaped wall of water called a bow wave. Bow waves are familiar sights in front of boats as well, and can also be formed in the atmosphere and in space when objects move more rapidly than the speed of waves in their liquid or gas environments.

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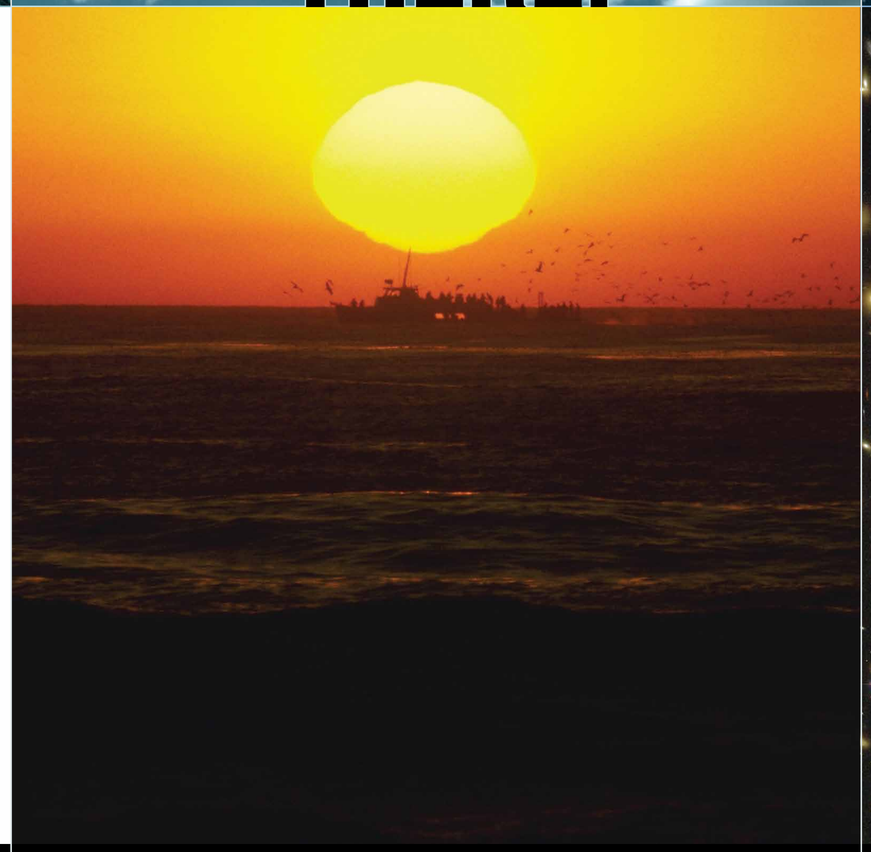
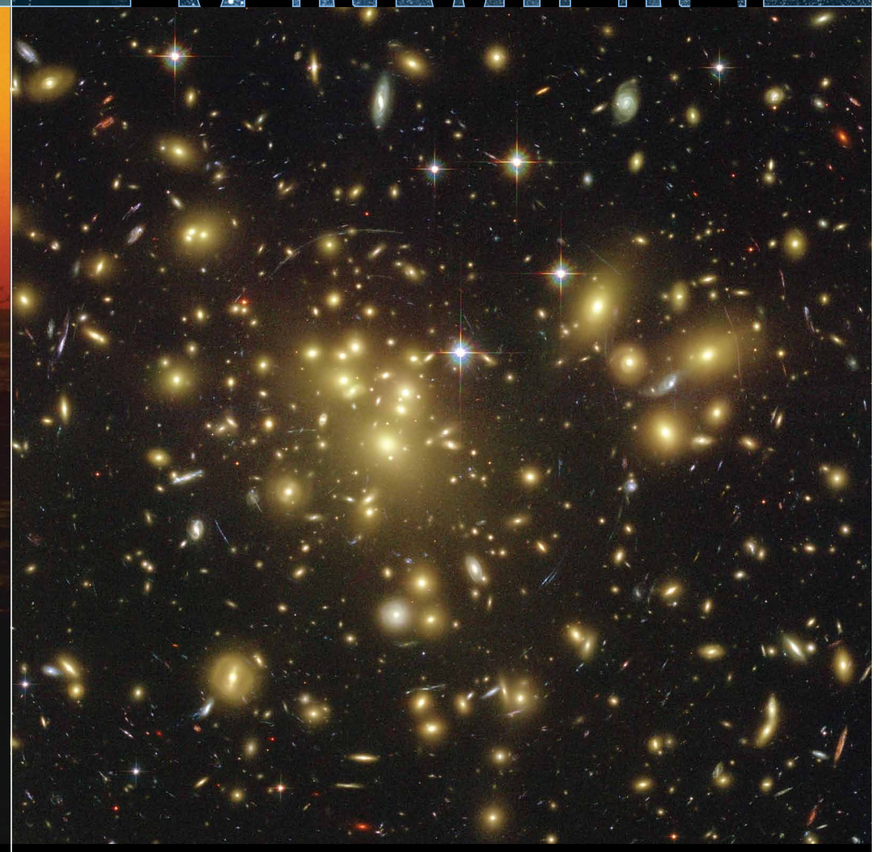
Eyeglasses.

Our eyes contain natural lenses. Sometimes, however, they do not adequately focus light onto the retina and corrections like eyeglasses or contact lenses are needed. These corrective tools are typically made of glass or plastic, which is specially shaped to bend incoming light so that it focuses properly on the retina of the eye.



Sunset.

The Sun is a sphere, not the misshapen oval that appears in this picture. The distortion happens because the Earth's atmosphere is acting as a lens. Light from the bottom of the Sun is being bent more than from the top because the light must pass through more of the atmosphere the closer we look to the horizon. The effect is that the apparent location of the bottom of the Sun is raised more than the top, making the whole Sun look oval-shaped.



Gravitational Lensing.

In the early 20th century, Albert Einstein realized that space can be significantly curved by an extremely massive object. Since light follows the curvature of space, a massive object can act as a gravitational lens. We see the effect of gravitational lensing in this image. The light from very distant galaxies has passed through a massive cluster of galaxies that acts as a lens and bends the light. The result is that the images from the galaxies are magnified and distorted into elongated and arched shapes.

BENT LIGHT When the path of a light ray is bent, the image of the light source becomes distorted. For example, a magnified image is produced by the bending of light as it passes from the air into the lenses of eyeglasses. Likewise, the setting Sun appears flattened because sunlight is bent as it travels through the atmosphere. Light paths can also be bent through the warping of space by a massive galaxy or galaxy cluster, which acts as a gravitational lens that distorts the images of more distant background galaxies.

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