

Highlights™



Spotlight  
on  
**SPACE**

# Table of Contents

LEXILE<sup>®</sup> MEASURE

<b>3</b>	<b>Copernicus, King of Craters .....</b>	<b>870L</b>
<b>4</b>	<b>Catching Andromeda’s Light .....</b>	<b>890L</b>
<b>6</b>	<b>Merry Christmas from the Moon! ...</b>	<b>810L</b>



object—either a rocky asteroid or an icy comet—was more than a mile in diameter.

Still, there are larger craters on the Moon, so why is Copernicus special? The answer is simple: because the crater faces Earth directly, it looks nice and round, exactly the way everyone thinks a crater should look.

But what really makes Copernicus special is its halo of rays. These wispy streamers stretch outward in every direction. Like the crater itself, they are brightest when the Moon is full. Take a close look at these feather-like splashes.

When a big object blasts out a crater, the smallest particles travel farthest from the point of impact. This spray of rock then falls in a splash pattern onto the lunar surface. This material looks bright because it's made up of crushed and broken rock, which

# Copernicus, King of Craters

By Edmund A. Fortier

On the Moon, this crater rules.

**T**he best-known impact crater on Earth is Meteor Crater. It is nearly a mile across and about 550 feet deep. To see it, you would have to drive far out into the desert in Arizona.

The Moon's best-known meteor crater is Copernicus. It is 58 miles in diameter and more than 2 miles from top to bottom. To see it, you just have to step outside and look at the Moon through binoculars.

You may have already noticed that the Moon's surface is a mix of bright and gray areas. The gray areas are lava plains. The largest and darkest lava plains are found along the left-hand side of the Moon. Using binoculars, look just

to the left of the Moon's center. You'll see a small bright spot against the gray. That's Copernicus.

Since the Moon doesn't have an atmosphere to protect it as Earth has, tiny grains of space debris called meteoroids collide with the Moon constantly. This meteoroid "rain" wears down the lunar surface, creating a layer of dust. Meteoroids the size of rocks and boulders strike the Moon less often, but they are more powerful. These rocks can produce craters measuring anywhere from a few feet to several miles across. On rare occasions, the Moon is hit by an object the size of the one that carved out Copernicus. That

reflects light better than the dust-covered lava plain.

Over long periods of time, the constant bombardment by meteoroids darkens the rays and mixes them with the surface dust. Eventually the rays disappear. Copernicus's rays are still bright because this crater is young. It's only 810 million (810,000,000) years old. Many other large craters are nearly 4 billion (4,000,000,000) years old.

The crater is named after the great astronomer Nicolaus Copernicus. In the 1800s, another astronomer studied this scar on the Moon's surface. He called it "the Monarch of the Moon." Today, we can call it the king of craters. 

# Catching Andromeda's Light

By Ken Crowell, Ph.D.  
Photo by Robert Gendler

**T**he Andromeda Galaxy is the closest giant galaxy to our own. By observing Andromeda, astronomers have learned a lot about our Galaxy, the Milky Way.

## A Spiral Galaxy

In 1887, Isaac Roberts, an astronomer in Wales, discovered that Andromeda is a *spiral* galaxy—the most beautiful type. He made his discovery by photographing the galaxy. Unlike the eye, photographs can collect dim light for hours. Then they show faint things that the eye can't see.

What about the Milky Way Galaxy? People wondered whether it was a spiral, too. But they couldn't tell. We live in the Milky Way, so we can't see it from the outside.

Astronomers counted the Milky Way's stars in different directions. They hoped to see a spiral pattern. But they didn't succeed.

Fortunately, the Andromeda Galaxy helped. Walter Baade, an astronomer in America, took a photograph that showed red clouds of gas that lined up with Andromeda's spiral arms.

Another astronomer in America, William Morgan, saw that photograph and had an idea. Since red clouds of gas trace

**Spiral arms**

**M32**

**Giant black hole**

*Andromeda's spiral arms arise because the galaxy is spinning. Appearing above and below Andromeda are two smaller galaxies, which are orbiting around it.*

**A galaxy is a huge collection of stars, gas, and dust that are held close to one another by gravity.**

Andromeda's spiral arms, he thought they might also trace the Milky Way's spiral arms. So in 1951,

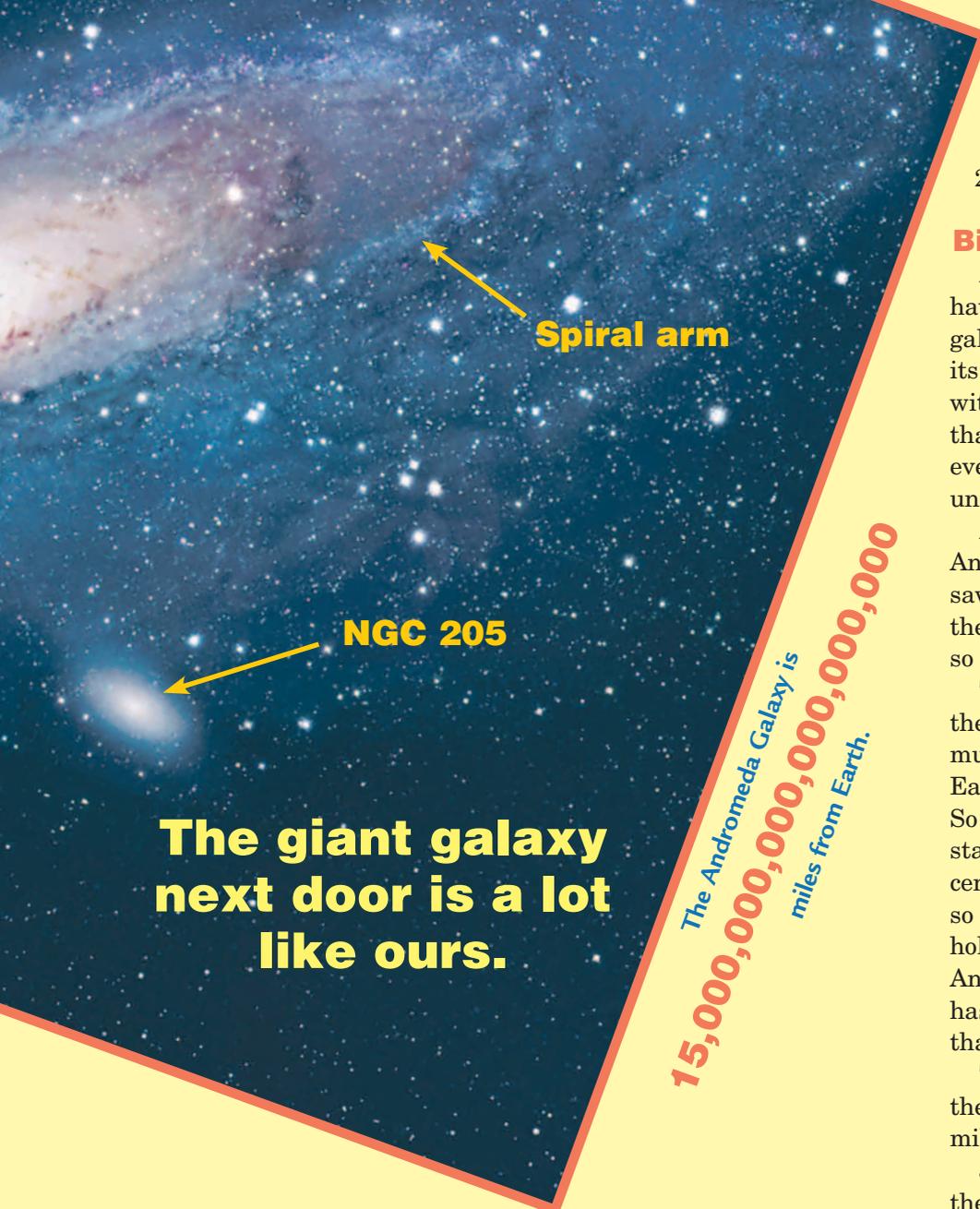
Morgan mapped the locations of all the red clouds of gas he and his colleagues could find. He discovered that the gas clouds lined up along spiral arms, indicating that we live in a spiral galaxy.

Why do red clouds of gas trace the spiral arms? It's because spiral arms give birth to stars. The brightest newborn stars are hot and blue, so spiral arms are blue. The blue stars give off ultraviolet radiation—light waves that are shorter than your eye can see. This ultraviolet light carries lots of energy and makes gas glow red. So, strangely enough, gas can turn red when it's near blue stars.

The stars of Andromeda even reveal how far away the galaxy is. It works like this. Astronomers observe a type of star in Andromeda. Then they compare the star with the same type of star in the Milky Way. The fainter the star in Andromeda looks, the farther away Andromeda must be.

It's like seeing a distant streetlight. By comparing its faintness with the streetlight in front of your home, you can estimate how far the distant streetlight is.

Andromeda is 2.5 million (2,500,000) light-years away. One light-year is a long way: it's the distance light travels in a year, about 5.88 trillion



**The giant galaxy next door is a lot like ours.**

*The Andromeda Galaxy is 15,000,000,000,000,000 miles from Earth.*

larger than M32, is called NGC 205.

### **Big Black Holes**

Andromeda and the Milky Way have even more in common. Each galaxy has a giant black hole at its center. A black hole is an object with so much mass and gravity that nothing can escape it—not even light, the fastest thing in the universe.

Astronomers discovered Andromeda’s black hole after they saw that the stars and gas near the galaxy’s center move fast. Why so fast?

The Earth moves fast around the Sun. But if the Sun had much more mass than it does, the Earth would move much faster. So the very high speed of the stars and gas near Andromeda’s center means there must be so much mass that it’s a black hole! Astronomers calculate that Andromeda’s central black hole has 140 million times more mass than the Sun.

The black hole at the center of the Milky Way is smaller—only 4 million times the mass of the Sun.

Just as the Earth goes around the Sun, the Sun goes around the Milky Way’s big black hole. But don’t worry: the black hole is 27,000 light-years away. Plus, the Sun moves half a million miles per hour—so fast that it won’t fall into the black hole. All other stars in the Milky Way also move around the black hole at the Galaxy’s center.

Likewise, all the stars in the Andromeda Galaxy move around its central black hole. Perhaps some of those stars have planets with intelligent beings who have learned a lot about their galaxy—by observing ours. **4**

(5,880,000,000,000) miles. So the Andromeda Galaxy is about 15 quintillion (15,000,000,000,000,000) miles from Earth.

Believe it or not, that’s not very far—at least, as galaxies go. Andromeda is so close that it is part of the Local Group of galaxies.

The Local Group has dozens of galaxies. Andromeda is the brightest one in the Local Group. Our Galaxy, the Milky Way, ranks number two.

### **Galactic Empires**

Both Andromeda and the Milky Way are giant spiral galaxies. Each galaxy is so large that many other galaxies go around it, just as the Moon goes around the Earth. We call these smaller galaxies “satellite galaxies,” for the same reason we call the Moon a satellite of the Earth.

The photograph here shows two of Andromeda’s satellite galaxies. The round one that appears above Andromeda’s disk is called M32. The oval one below, which looks

# Merry Christmas from the Moon!

By Edmund A. Fortier

**E**very December, people around the world celebrate the holiday season by sending greetings to family and friends. But in 1968 something unusual happened. The world received a Christmas greeting from the Moon.

The message was from the crew of *Apollo 8*, which was 240,000 miles from Earth. On Christmas Eve, *Apollo 8* was circling the Moon in an orbit just sixty-nine miles above the cratered surface. The three astronauts on board were all looking forward to the trip home, which would begin in the morning. But first they were going to make a final broadcast for tele-vision. Back on Earth, half a billion people were waiting to see it.

*Apollo 8* was the first manned spacecraft to orbit the Moon. The crew's mission was to test the ship, which was made up of a *command module* and a *service module*. In future missions, a *lunar module* would be added to land the first astronauts on the Moon. Anything might go wrong. So far, nothing had. But the crucial firing of the rocket that would return the men to Earth was still to come. If the rocket engine failed, the men would be trapped in lunar orbit with no hope of rescue.

The commander of *Apollo 8*, Frank Borman, knew the world would be watching. He had

brought along a passage to read, but he had been too busy to plan the whole telecast. Then he and his crew, Jim Lovell and Bill Anders, saw something wonderful as they orbited the Moon. Borman knew at once what he wanted to do. But it would take some planning. It had to be timed just right.

Borman began the telecast. First, each man gave his impressions of the Moon. Next, the astronauts pointed out different features on the surface as it slowly passed below them. All this time, the planned moment had been drawing closer and closer. When the time

**No human  
had ever seen  
Earth like this  
before.**

arrived, Borman and his crew were ready. Anders announced that the crew of *Apollo 8* had a message for Earth. In turn, Anders, Lovell, and Borman read the Bible passage Borman had brought with him. It was the story of Creation from the Book of Genesis. As the men read, a camera on *Apollo 8* was pointed forward, toward the Moon's horizon. The wonderful sight the men had marveled at was now on television screens around the world.

No one on Earth had ever seen it before. There, above the lifeless lunar landscape, the distant Earth was rising. It looked like a fragile holiday ornament.

That image was a Christmas present to the world from the crew of *Apollo 8*. ❧

This famous photograph was taken by the *Apollo 8* crew on December 24, 1968. They were the first people to see Earth from so far away. That night, in a history-making broadcast, they shared this sight with the rest of the world.

