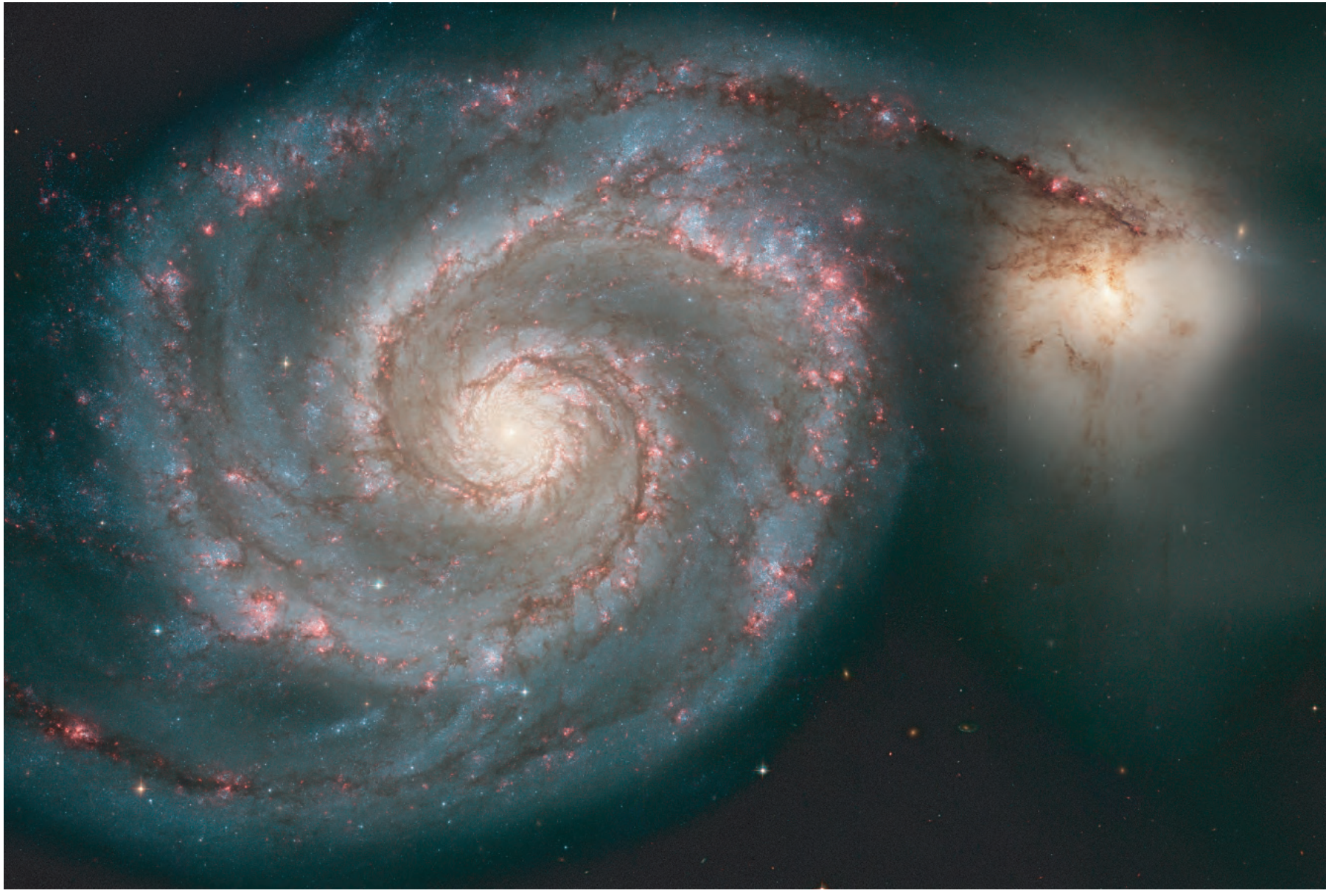
National Aeronautics and Space Administration
Goddard Space Flight Center

The Whirlpool Galaxy (M51) and Companion Galaxy



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Out of This Whirl

The graceful, winding arms of the majestic spiral galaxy M51 appear like a grand spiral staircase sweeping through space. They are actually long lanes of stars and gas laced with dust.

This sharpest-ever image, taken with NASA's Hubble Space Telescope, illustrates a spiral galaxy's grand design, from its curving spiral arms, where young stars reside, to its yellowish central core, a home of older stars. The galaxy is nicknamed the Whirlpool because of its swirling structure.

The Whirlpool's most striking feature is its two curving arms, a hallmark of so-called grand-design spiral galaxies. Many spiral galaxies possess numerous, loosely shaped arms which make their spiral structure less pronounced. These arms serve an important purpose in spiral galaxies. They are star-formation factories, compressing hydrogen gas and creating clusters of new stars. In the Whirlpool, the assembly line begins with the dark clouds of gas on the inner edge, then moves to bright pink star-forming regions, and ends with the brilliant blue star clusters along the outer edge.

Some astronomers believe that the Whirlpool's arms are so prominent because of the effects of a close encounter with NGC 5195, the small, yellowish galaxy at the outermost tip of one of the Whirlpool's arms. At first glance, the compact galaxy appears to be tugging on the arm. Hubble's clear view, however, shows that NGC 5195 is passing behind the Whirlpool. The small galaxy has been gliding past the Whirlpool for hundreds of millions of years.

As NGC 5195 drifts by, its gravitational muscle pumps up waves within the Whirlpool's pancake-shaped disk. The waves are like ripples in a pond generated when a rock is thrown in the water. When the waves pass through orbiting gas clouds within the disk, they squeeze the gaseous material along each arm's inner edge. The dark dusty material looks like gathering storm clouds. These dense clouds collapse, creating a wake of star birth, as seen in the bright pink star-forming regions. The largest stars eventually sweep away the dusty cocoons with a torrent of radiation, hurricane-like stellar winds, and shock waves from supernova blasts. Bright blue star clusters emerge from the mayhem, illuminating the Whirlpool's arms like city streetlights.

The Whirlpool is one of astronomy's galactic darlings. Its beautiful face-on view and closeness to Earth allow astronomers to study a classic spiral galaxy's structure and star-forming processes.

VOCABULARY

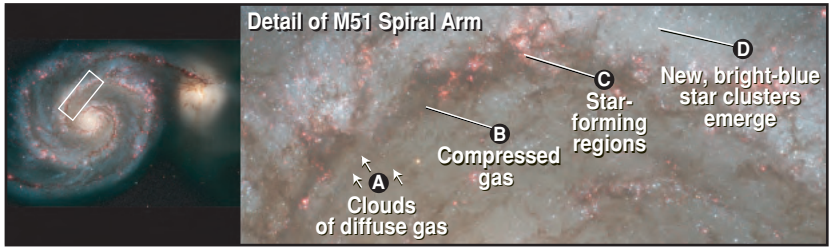
Galaxy: A collection of stars, gas, and dust bound together by gravity.

Stellar wind: Streams of charged particles flowing from the star at millions of kilometers per hour.

FAST FACTS

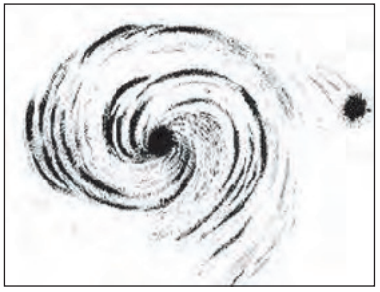
Location: Constellation Canes Venatici (the Hunting Dogs)
Distance from Earth: 31 million light-years
Width (of entire ACS image): 90,000 light-years

Credits: NASA, ESA, S. Beckwith (STScI), and the Hubble Heritage Team (STScI/AURA)



Density-wave theory and spiral galaxies *(above)*. (*A*) Gas in galaxies exists in huge, wispy clouds. (*B*) When these clouds encounter a density wave, they compress into dark, dense gas clouds, called dust lanes. The densest pockets within these dark gas clouds collapse and form stars. (*C*) Thousands of stars are born together in a bright pink star-forming region. (*D*) The largest stars blow away the remaining gas, uncovering bright blue star clusters on the other side of the spiral arm.

Drawing of Messier 51 by William Parsons, the Third Earl of Rosse, compared with Hubble's ACS image (*below, right*). In 1845, Irish astronomer Lord Rosse pointed his 6-foot-wide telescope, the largest of its day, at a mysterious smudge of shimmering light. French astronomer Charles Messier, 72 years earlier, had named the glowing blob M51. But Messier's blob took on a more intricate form with Lord Rosse's powerful telescope. To the Irish astronomer's surprise, the shimmering smudge had a striking pinwheel shape which no one had ever seen before. Lord Rosse called M51 a "spiral nebula," not realizing that the object was a faraway galaxy brimming with stars. His drawing of M51 looks strikingly similar to the image snapped by Hubble's Advanced Camera for Surveys.



You can get images and other information about the Hubble Space Telescope on the World Wide Web. Visit **http://www.stsci.edu/outreach** and follow the links.

The corresponding Classroom Activity for this lithograph can be found at: **http://amazing-space.stsci.edu/** or may be obtained by contacting the Office of Public Outreach at the Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218.

STScI L-05-01 LG-2005-3-089-GSFC

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In Search of . . . Interacting Galaxies

Description

Using the "Whirlpool Galaxy (M51) and Companion Galaxy" lithograph, engage your students in a Level One Inquiry activity to introduce the topic of interacting galaxies. A Level One Inquiry activity can help prepare students to be more independent thinkers. Students conduct research to answer questions they have about interacting galaxies.

Grade Level

Middle – high school: Grades 8–12

Prerequisites

At the very least, students should be aware that galaxies are groups of stars, gas, and dust that are held together by gravity, and they don't necessarily look alike. Teachers should be aware of their students' knowledge concerning galaxies and use the information presented below and elsewhere to help them successfully complete this activity.

Misconceptions

Teachers should be aware of the following common misconceptions and should determine whether their students harbor any of them. Students may have misconceptions regarding the astronomical meaning of interacting galaxies.

When two galaxies come close enough for the gravity of one to exert a distorting effect on the other, the galaxies are interacting. Students may also picture stars bumping into each other as two galaxies interact or even merge. Vast distances, however, separate the large numbers of stars in galaxies. When galaxies merge, their stars pass by each other and usually do not collide. Galaxies are so far away that they appear as fuzzy patches in the sky. Only three are visible with the unaided eye: the Andromeda Galaxy and the Large and Small Magellanic Clouds.

Vocabulary

Interacting Galaxies: When two galaxies pass close enough to gravitationally disrupt each other's shape. The interaction rips streamers of stars from the galaxies, fuels an explosion of star birth, and can ultimately result in both galaxies merging into one. Note: The stars in each galaxy are far apart and usually do not collide when galaxies merge.

Galaxy: A collection of stars, gas, and dust bound together by gravity. The smallest galaxies may contain only a few hundred thousand stars, while the largest galaxies have thousands of billions of stars. The Milky Way Galaxy contains our solar system. Galaxies are classified or grouped by their shape. Round or oval galaxies are elliptical galaxies. Those showing a pinwheel structure are spiral galaxies. All others are called irregular because they do not resemble elliptical or spiral galaxies.

Gravity (Gravitational Force): The attractive force between all masses in the universe. All objects that have mass possess a gravitational force that attracts all other masses. The more massive the object, the stronger the gravitational force. The closer objects are to each other, the stronger the gravitational attraction.

See the lithograph for additional vocabulary terms.

Purpose

The purpose of this activity is to apply a Level One Inquiry technique using images and text to introduce the topic of interacting galaxies. In this activity, the components of inquiry learning that students can practice are: asking questions, planning and conducting investigations, using critical thinking skills, and communicating results. Students will make observations, formulate questions, and read for a purpose.

Materials

- "Whirlpool Galaxy (M51) and Companion Galaxy" lithograph
- Magnifying glass
- Computer with Internet connection for researching
  — Electronic images from the "Whirlpool Galaxy (M51) and Companion Galaxy" lithograph and related links are available at **http://hubblesite.org/news/2005/12**.

Instructions for the Teacher

Preparation

- Obtain a lithograph for each student.
- Make arrangements to use the media center and/or the computer lab with Internet connections.

Procedure

Ask students to look at the image of the Whirlpool Galaxy on the front of the lithograph and/or read the information on the back. Ask them to write down three questions they want answered about interacting galaxies. They should examine the image on the front of the lithograph or read the text on the back for inspiration. Allow students to refine their questions by discussing them with classmates. Another option is to have students share their questions with the class and work with the class on refining them. After gathering the questions, identify the most commonly asked questions and briefly analyze them with students.

Then ask students to use a magnifying glass to search for smaller details in the image. Students also can research textbooks, encyclopedias, and/or the Internet for more information about the galaxy. For a more detailed look at the galaxy, use the link in the Materials section above. Go to the main menu on the left and click on "Images" to see a selection of available photos. Students can work individually or can be placed in groups based upon common questions/interests. Students can report their findings in a variety of ways: written reports, oral reports, and/or posters or other visual aids.

Instructions for the Student

Study the image of the Whirlpool Galaxy and read the back of the lithograph. Then write down three questions that you want answered about interacting galaxies. Examine the image on the front of the lithograph and/or read the text on the back for inspiration. Be prepared to share your questions with the class. Your teacher will ask you to learn more about interacting galaxies by researching textbooks, encyclopedias, and/or the Internet. For a more detailed view of the Whirlpool Galaxy image, use the Internet to view the digital photos.

Education Standards

Benchmarks for Science Literacy

American Association for the Advancement of Science:

http://www.project2061.org/tools/benchol/bolframe.htm

The Physical Setting

A. The Universe

By the end of the 8th grade, students should know that:

- The Sun is a medium-sized star located near the edge of a disk-shaped galaxy of stars, part of which can be seen as a glowing band of light that spans the sky on a very clear night. **The universe contains many billions of galaxies, and each galaxy contains many billions of stars. To the naked eye, even the closest of these galaxies is no more than a dim, fuzzy spot.**

National Science Education Standards

http://books.nap.edu/html/nses/

Content Standard B: As a result of their activities in grades 9–12, all students should develop an understanding of motions and forces.

- **Gravitation is a universal force that each mass exerts on any other mass.** The strength of the gravitational attractive force between two masses is proportional to the masses and inversely proportional to the square of the distance between them.

McREL Language Arts Standard and Benchmarks

http://www.mcrel.org/compendium/standardDetails.asp?subjectID=7&standardID=7

Reading Standard 7:

Level 3 (Grades 6–8) and Level 4 (Grades 9–12)

1. Uses reading skills and strategies to understand a variety of informational texts (e.g., textbooks, biographical sketches, letters, diaries, directions, procedures, magazines, essays, primary source historical documents, editorials, news stories, periodicals, catalogs, job-related materials, schedules, speeches, memoranda, public documents, maps)