



M82: A Starburst Galaxy

M82: The Case of an Odd-looking Galaxy

High up in the Big Dipper lies a weird-looking galaxy. Fiery-looking plumes of gas are pouring out of the galaxy's center. Unusual dark lanes of dust appear to have woven a web around the galaxy's blue disk of stars.

The plumes and the dust lanes are a telltale sign that something violent happened to the galaxy, called Messier 82, or M82. Astronomers have been collecting clues to crack the case. Most of the evidence may lie buried deep inside M82's core, where giant clouds of gas are collapsing simultaneously under the pull of gravity.

Within these clouds, young stars are forming at a furious rate. For every star born in our Milky Way Galaxy, 10 stars are forming in M82. The flurry of star birth is reminiscent of the end of a pyrotechnics show, with a string of fireworks popping off at the same time. Astronomers call galaxies like M82 starburst galaxies.

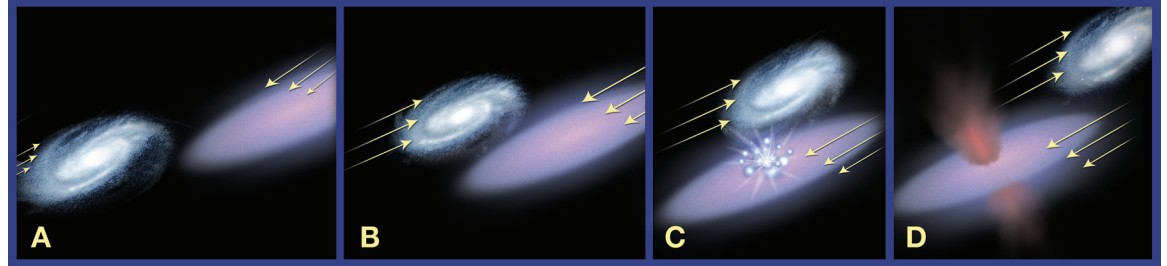
The evidence shows that the star-birth firestorm probably began hundreds of millions of years ago. What ignited it? Astronomers believe that a close encounter with another galaxy stirred up the gas in M82. The turbulent gas crashed together, compressed, and collapsed under gravity, triggering widespread star formation.

But no one was around millions of years ago to witness the near-collision. So astronomers have not fingered the culprit, but they have three suspects.

M82 may be limping away from a close encounter with one or two nearby galaxies, M81 and NGC 3077. These galaxies cannot be seen in the Hubble image. The two suspect galaxies are linked to M82 because they show signs of an interaction with another galaxy.

Some astronomers believe, however, that NGC 3077 was not involved in the crime at all, but may have been born when M81 and M82 passed near each other. A third suspect is a galaxy that cannot be seen because it may have been swallowed up by M82.

Although astronomers have not nabbed the culprit that helped trigger the starburst, they have determined what is producing the plumes of gas seen coming from the galaxy's center. When star formation in a small region



Reenacting the crime: One possible scenario

This illustration shows one of several possible near-collision scenarios between M82 and another galaxy. Astronomers do not know which galaxy brushed by M82. In this scenario, an encounter between M82 and another galaxy triggers a flurry of star birth. Panels A and B show two galaxies on a collision path. M82 is the bluish-pink galaxy. In Panel C, the galaxies

already have interacted. One galaxy is moving away. The encounter stirs up gas in M82, which compresses and collapses under gravity, creating new stars. The young stars are crammed together in clumps or clusters of up to a million stars. The largest, brightest stars are blowing gas, like a fountain, out of the galaxy's center, shown in Panel D.

becomes too vigorous, a large amount of gas is driven out of the galaxy. The flame-like plumes of gas streaming from M82 are evidence of this kind of star formation. The rapid star birth will eventually blast away the material needed to make more stars.

Starbursts like this one may be a brief and violent phase in the early lives of galaxies. Billions of years ago, when the universe was young, encounters between galaxies were more abundant. M82, therefore, is a nearby laboratory where astronomers can study what happens when galaxies meet. Astronomers will have plenty of time to study the crime scene in M82. The starburst is expected to last a few tens of millions of years.

FAST FACTS

Distance from Earth: 12 million light-years

Constellation: Ursa Major (the Great Bear)

VOCABULARY

Starburst galaxy: A galaxy in which rapid star formation is occurring or has occurred in the recent past. Astronomers think the rapid star birth is caused by a gravitational interaction with another galaxy.

Credits: NASA and the NASA Jet Propulsion Laboratory.

You can get images and other information about the Hubble Space Telescope on the World Wide Web. Visit <http://hubblesite.org> and follow the links.

The corresponding classroom activity for this lithograph can be found at: <http://amazing-space.stsci.edu/eds/overviews/print/lithos/m82.php>, or may be obtained by contacting the Office of Public Outreach at the Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218.

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In Search of ... Starburst Galaxies

Description

Use the “M82: A Starburst Galaxy” lithograph as the initial source of information to engage your students in a Level One Inquiry activity. Students will use the images and text to generate questions about the cause of the starburst, a rapid rate of star formation, in M82. They also will conduct research to answer their questions. Students then will identify the galaxy they think is responsible for igniting the star formation in M82, and must provide evidence to support their choice. This activity is a curriculum support tool designed to be used as an introductory inquiry activity. It can be incorporated into a unit that has a scientific inquiry and/or a galaxy evolution theme.

About Inquiry-based Learning:

The inquiry process is driven by the student’s own curiosity, wonder, interest, or passion to understand an observation or solve a problem. It involves a process of exploring the natural or material world. This exploration prompts students to ask questions and make discoveries in the search for new insights. A Level One Inquiry activity uses questions and problem-solving methods directed by the teacher. In the M82 lithograph activity, teachers use the M82 image to help students ask questions about the odd-looking galaxy. Teachers suggest selected resources about starburst galaxies to help students answer their questions. Students then determine the answers to their questions and provide supporting evidence for them. This process can help prepare students to be more independent thinkers. Note: The preparation section below can direct you to resources for inquiry-based learning.

Grade Level

High school: grades 11–12

Prerequisites

Students should be aware that galaxies are collections of stars, gas, and dust bound together by gravity. They should also know that the stars within galaxies vary in brightness, color, mass, temperature, and age.

Misconceptions

Teachers should be aware of the following common misconceptions and determine whether their students harbor any of them. Students may have misconceptions concerning the visibility of galaxies in the night sky. Most galaxies are so far away that people can view them only with the help of telescopes. Other than our galaxy, the Milky Way, only three galaxies can be seen with the unaided eye: the Andromeda Galaxy and the Large and Small Magellanic Clouds.

Purpose

The purpose of this activity is to use the images and text on the lithograph to generate questions about the cause of the rapid rate of star formation in M82. Students will use the Internet to search for the answers to their questions. They also will identify the galaxy they think is responsible for igniting the star birth. Students then will organize their material and present a report identifying the galaxy they think is responsible for the starburst in M82, offering evidence to support their choice. Teachers will ask students if they answered their original questions and/or if, while researching, they came up with any new questions.

Materials

- “M82: A Starburst Galaxy” lithograph
- Computer with Internet connection for researching

Instructions for the Teacher

Preparation

- Obtain a lithograph for each student. The lithograph is available as a PDF file at: <http://amazing-space.stsci.edu/capture/galaxies/preview-m82.php>.
- Preview the Overview page found at: <http://amazing-space.stsci.edu/eds/overviews/print/lithos/m82.php>. Use the “Related Resources” to (1) become familiar with inquiry-based learning and/or (2) familiarize yourself with M82 and the cause of starbursts in galaxies.

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Procedure

Before beginning this activity, evaluate your students' misconceptions about galaxies and stars by having them write down anything they know and understand about these topics. You can use these statements to evaluate your students' misconceptions. Have students volunteer their ideas about galaxies and stars. From those ideas, identify their misconceptions and discuss them with the class. Or, collect their papers containing their ideas about galaxies and stars. From those ideas, compile a list of their misconceptions and discuss them with the class.

Ask students to look at the image of M82 on the front of the lithograph and write three questions about the features visible in the image.

Collect these questions and group them by common themes. Ask students to read the information on the back of the lithograph, then check to see if any of their questions were answered. Using the Internet, have students research their questions. The Internet sites listed on the preview page provide a starting point for their research. Tell students how to access other Websites.

Ask students to prepare a report in which they identify the galaxy they think is responsible for the starburst in M82, providing supporting evidence for their choice. This report could be in the form of a slide show, a skit, a story, a graphic organizer, a Power Point presentation, or a written report — anything that conveys their understanding of the topic to another student, a group of students, or the entire class. Ask students to review their original questions to see if they were answered. Then ask them if they have any additional questions.

Instructions for the Student

Your teacher will ask you to write down things you know and understand about galaxies and stars. You may be asked to share this information with the rest of the class. Study the image of M82 and write down three questions about what you see in the image. Then read the back of the lithograph, and check to see if any of your questions were answered.

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Using your questions as a guide, conduct an Internet research on M82 to find the cause of the rapid star formation. Your teacher will guide your search by providing some Websites to use. To demonstrate your understanding of the material you researched, your teacher will ask you to present a report in which you identify the galaxy responsible for the starburst and explain your reasoning. This report could be in the form of a slide show, a skit, a story, a graphic organizer, a Power Point presentation, or whatever presentation you think will communicate the information you learned about M82. You may be allowed to work individually or in small groups. You may make your presentations to another classmate, another group of students, or the entire class.

Education Standards

National Science Education Standards

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

Science As Inquiry

Content Standard A: As a result of activities in grades 9-12, all students should develop understandings about scientific inquiry:

- Scientific explanations must adhere to criteria such as: a proposed explanation must be logically consistent; it must abide by the rules of evidence; it must be open to questions and possible modification; and it must be based on historical and current scientific knowledge.

Project 2061

1. The Nature of Science

B. Scientific Inquiry

By the end of the 12th grade, students should know that:

- Investigations are conducted for different reasons, including to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories.
- Sometimes, scientists can control conditions to obtain evidence. When that is not possible for practical or ethical reasons, they try to observe as wide a range of natural occurrences as possible so as to discern patterns.

Educational Product

Educators & Students Grades 10–12