



The Discovery of Jupiter Radio Waves

(How a Chance Discovery Opened up the
Field of Jovian Radio Studies)

Lesson #1

Lesson Plan: The Discovery of Jupiter Radio Waves

Objective: The students will be able to identify questions and concepts that guide scientific investigations, recognize and analyze alternative explanations and models by the end of this activity.

National Standards:

1. Content Standard A: Science as Inquiry
2. Content Standard G: History and Nature of Science

Course/Grade level: Earth/Space Science Course, Physics
Grade level: 8-12

Materials:

1. Article: The Discovery of Jupiter's Radio Emissions (How a Chance Discovery Opened up the Field of Jovian Radio Studies)
2. Discussion Questions: Student page

Estimated Time: 30-45 minutes for completion of the reading and student questions

Procedure:

1. **Engagement:** Introduction of the activity,
 - A. Ask the students to compile a list of information, things they know about the planet Jupiter.
 - B. Ask the students to list what they know about radio waves. Some prompting may be necessary, such as: where do the radio signals come from that you listen to, what types of things give off radio waves.
2. **Exploration:** Have the students read the article, stopping to discuss parts as needed.
3. **Explanation:** After reading the article, have the students complete the Discussion Questions.
4. **Extension:** Upon completion of the student questions, discuss any additional questions that the students might have derived from the reading, pulling out inferences that they might have made.
5. **Evaluation:** There is an additional question attached that is aimed at an understanding of the science involved in the article and at generating a connection to the Scientific Method used by the scientists.

TEACHER PAGE 1 : Possible Ideas for Engagement Questions:

A. Things students may know about Jupiter

- Jupiter is one of the planets like Earth.
- Like Earth, Jupiter orbits the Sun.
- Jupiter is a lot bigger than Earth, and is the largest planet.
- Jupiter is farther from the Sun than Earth.
- Jupiter is completely covered in clouds.
- Like Earth, Jupiter has a moon. In fact it has many moons!

B. Things students may know about radio waves

- You need a radio receiver to pick up radio waves.
- Radio waves are electromagnetic waves like light, but have a different frequency.
- Radio stations send out radio waves that can be picked up by a radio receiver many miles away.
- Sometimes if there is lightning outside you can hear loud noises on the radio especially if you are listening to AM radio.
- Radio waves can travel very great distances through space.
- Satellites can send signals down to Earth using radio waves. Receiving these signals is what those TV dishes on the roof of houses are for.
- You can learn things about space by listening to radio waves with special radio receivers.
- Radio waves are transmitted by accelerating charges.

Student questions with answers

1. Which direction did the Mills Array radio beam point? Straight up
2. Did the scientists identify more than one source of radio waves in the article? yes
3. What types of radio wave sources were mentioned that came from nearby objects? Power lines, cars
4. What is the relationship of the change of position of Jupiter in the sky to the radio wave data the scientists obtained? The change of Jupiter's position in the sky matched the changes in the pattern of the radio data: 4 minutes earlier each night.
5. Why does the position of Jupiter appear to move? Jupiter orbits the Sun like Earth and because of this it will appear to move when we compare its position to stars in the sky
6. When identifying a new radio wave source, what do scientists first need to rule out as the source? Scientists first eliminate everything that they already know emits radio waves. Nearby things like cars and power lines and then more distant things like stars and galaxies are eliminated from the list.
7. How do scientists use patterns in their data to make predictions? Scientists try to match patterns found in their data with patterns that occur in nature. The time that they heard this strange emission matched the time that Jupiter appeared in that part of the sky.
8. What was the course of action taken by the scientists once they discovered that Jupiter emitted radio signals? Once scientists discovered that Jupiter emits strong radio waves they presented their discovery to other scientists.
9. What do you feel is the importance of the scientist s sharing their newly found discovery? More new things can be learned when many scientists, with many points of view, work on a common problem.
10. If you heard a sound that you could not identify, what is the method you would use to figure out what it is? Follow the scientific method to understand new and unknown ideas. What are the steps the scientists took in discovering radio waves from Jupiter, and how are they similar to the steps you would take? The scientists took the information that they knew from prior research, eliminated that as the cause, continued to gather other, new data with an unknown origin, hypothesized what might be the cause, tested the hypothesis, then shared the results for others to verify once they felt confident in their conclusion.

Teacher Page 2

Quiz ANSWER KEY

Name _____

1. Explain how the use of the scientific method was involved in the discovery of Jupiter radio emissions? Be sure to elaborate on your knowledge of the scientific method and the actions taken by the scientists.

An important aspect of the article is that the scientists discovered the unknown radio emission by chance. They used the scientific method to identify and rule out various other radio sources. After repeated steps and continual observations, they were able to hypothesize that the source of the radio wave was not from Earth, nor was it from one of the previous observed objects from space. It is important to point out that before any hypothesis was made as to the source, the scientists had to make observations and conduct tests, which in turn had to be verified and changed many times. The scientists were able to verify their hypothesis by continuing their observations and showing that the emissions occurred only when Jupiter was at a location where it could be the radio source. Then they had sufficient confidence in their results to feel comfortable sharing their belief that the source of the radio emission was Jupiter.

The Discovery of Jupiter Radio Waves

(How a Chance Discovery Opened up the Field of Jovian Radio Studies)

By Dr. Leonard N. Garcia

Using a radio for astronomical research was still a relatively new idea when Bernard Burke and Kenneth Franklin of the Carnegie Institute in Washington D.C. discovered that the planet Jupiter was a strong source of radio waves.

In 1955 these two scientists were testing a new radio antenna called a Mills Cross Array which had been built a few miles outside of Washington D.C. The antenna was shaped like a gigantic "X" and covered 96 acres of land. Each leg of the X was over 2000 feet long and was made up of 64 dipole antennas. These dipole antennas were very similar to the dipole antennas used in the Radio Jove project. Each one looked like a wire stretched between two support poles with a connecting wire hanging down from the middle of it. [Actually the middle wire is a coaxial cable, which has a central wire, a layer of insulation around it, then another wire wound around the middle wire. The middle wire is connected to one half of the horizontally suspended wire and the outer wire is connected to the other half. This makes a Dipole .] The dipoles were connected such that the antennas acted like a single huge instrument. The array was designed to operate at a frequency of 22 megahertz (MHz). The direction from which radio waves could be picked up with the greatest sensitivity could be changed by changing the lengths of cable connecting the antennas. It so happened that Burke and Franklin had set the antenna direction to be nearly vertical. They left the array pointing in that direction and allowed the rotation of Earth to sweep the antenna across a path in the sky.

By this time astronomers knew of several sources of radio waves in the sky. One of them was the Crab Nebula in the constellation of Taurus. Burke and Franklin were going to use the Crab radio source to test how their antenna array was working. The tests seemed to go well but on a few of these occasions something appeared in their records that they could not identify. They thought at first it was some form of terrestrial interference. At these frequencies you can often get many different types of interference from very down-to-earth things such as car ignitions, power lines, etc. The first thing they noticed about this emission was that it appeared to occur at nearly the same time of night each time they heard it. After studying this interference over several more nights they realized that it didn't quite occur at exactly the same time.

It appeared to be occurring about 4 minutes earlier each night. This type of change with time is what they would expect from some celestial object since stars appear to rise 4 minutes earlier each night. So they knew it was very unlikely to be Earth-bound interference. Once they had several months of data they could track more precisely how

the timing of this interference changed. They found that it didn't quite move like the stars moved. This would eliminate any star, nebula or galaxy since they all appear to move across the sky at the same rate. Finally they realized that an object that happened to be near the Crab Nebula at the time they began hearing this interference was Jupiter. Jupiter, like Earth, orbits the Sun and its orbital motion would cause it to appear to move at a rate somewhat different from the background stars. The rate at which Jupiter moved matched the change with time of the strange interference found in the records. Finally on April 6, 1955 at a meeting of the American Astronomical Society, Burke and Franklin felt sufficiently confident about their results to announce their discovery of radio emission from Jupiter.

As news of this discovery spread other radio astronomers began pouring through their records to see if they had Jupiter emission in their data. One astronomer from Australia, C.A. Shain, found observations he had taken 5 years earlier that contained Jovian radio bursts that he hadn't recognized before. Very soon after radio emissions from Jupiter were discovered, scientists had a baseline of 5 years of data to work with! The data from long periods of monitoring Jupiter's radio behavior has proven vital for later discoveries.

Facts about the Mills Cross Array

- B. Y. Mills an Australian radio astronomer along with England's Martin Ryle developed this antenna design.
- Each leg of the array was made up of 64 pairs of unpainted wooden poles with wire stretched across their tops.
- The Mills Cross Array used by Burke and Franklin used more than 5 miles of wire.
- The radio instruments for the Array were originally housed in an Army surplus truck on site.

Student Questions

Name _____

Date _____

Directions: Use the article you just read and the information from the class discussion to answer the following questions. Use a separate sheet of paper if needed.

1. Which direction did the Mills Array radio beam point? _____
2. Did the scientist identify more than one source of radio waves in the article? _____
3. What types of radio wave sources were mentioned that came from nearby objects? _____
4. What is the relationship of the change of position of Jupiter in the sky to the radio wave data the scientists obtained? _____

5. Why does the position of Jupiter appear to move? _____

6. When identifying a radio wave source, what do scientists first need to rule out as the source? _____

7. How do scientists use patterns in their data to make predictions? _____

8. What was the course of action taken by the scientists once they discovered that Jupiter emitted radio signals? _____

9. What do you feel is the importance of the scientist's sharing their newly found discovery? _____

10. If you heard a sound that you could not identify, what is the method you would use to figure out what it is? What are the steps the scientists took in discovering radio waves from Jupiter, and how are they similar to the steps you would take? _____

