TOPIC 5 What Channel Is That?

Light isn't the only kind of radiation coming from the stars. In the late nineteenth century, scientists found out that light is just one form of **electromagnetic radiation**. Other forms include radio waves, infrared waves (heat), ultraviolet waves, X rays, and gamma rays. Look at Figure 5.33. This shows the entire spectrum of electromagnetic radiation. Notice that light waves occupy only a small portion of the entire spectrum. In Topic 5, you will focus on radio waves and how astronomers use them to learn about the composition of stars — **radio astronomy**.

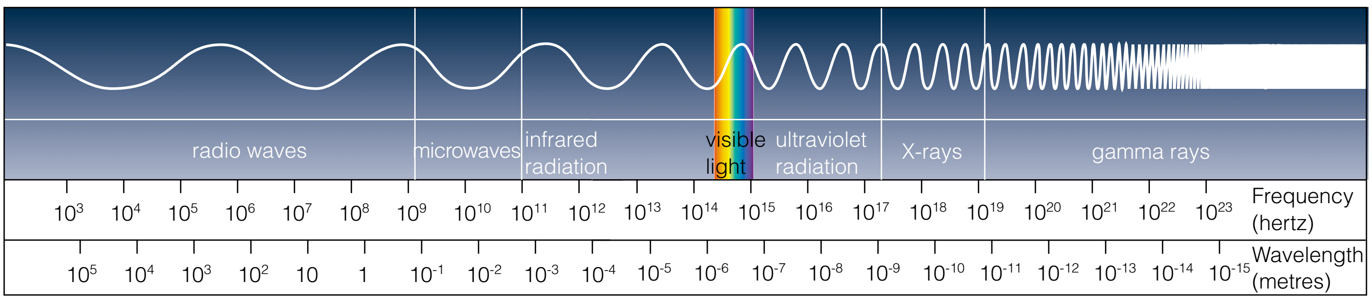

Figure 5.33 The electromagnetic spectrum.

Find Out **ACTIVITY**

Give Me Some Static!

Lightning bolts emit radio waves. In fact, any static electric sparks do the same. In this activity, you will make static sparks and try to detect radio waves from them.

Materials

small A.M./F.M. radio
wool
plastic
fur or hair

Procedure

Performing and Recording
Communication and Teamwork

1. Experiment to find a way to get a fairly good static shock with the materials provided.
2. Tune the radio between two A.M. stations. You should hear a hissing sound.
3. Bring the radio close to where you make a static spark. Listen on the radio for the static electricity to "broadcast" on the radio.
4. Repeat step 3 several times but at different frequencies (between different stations). Record your findings in your notebook.
5. Switch to F.M. and repeat step 3 at different frequencies.

What Did You Find Out?

Analyzing and Interpreting

1. Could your radio pick up the static on A.M.? On F.M.?
2. Why do you think that lightning causes problems for radio listeners?
3. Name three things in your house that might make static shocks. Do they cause radio interference?

Cool Tools

Astronomers were able to adapt radar equipment used in World War II to become the first radio telescopes. This was quite simple because radar equipment emits and detects radio waves. When radar equipment emits radio waves, the waves reflect off an object allowing the distance to the reflecting object to be calculated. However, astronomical radars do not emit radio waves because there are no objects reflecting them. Instead, the astronomical radars (the radio telescopes) simply detect radio waves emitted from objects in space.

Did You Know?

Reber found that the object outside of the solar system producing the strongest radio waves (called the brightest radio object) is the centre of our galaxy — the Milky Way. The Sun is the brightest of all the radio objects in the sky, and Jupiter is the second brightest.

Radio Telescopes

Telephone calls used to be transmitted by radio waves. The reception was poor, and people had to shout over hiss and noise on the line. In 1932, Karl Jansky, an engineer working for Bell Telephone Laboratories, was given the job of tracking down the radio emissions that were interfering with these communications. Jansky built a radio antenna. Using this antenna, he learned to identify radio emissions that rose and set with the Sun, planets, and stars. From these observations, he concluded that these radio wave sources came from space.

Figure 5.34 The world's first radio telescope (inset) by Karl Jansky, marked a big moment in science as was Galileo's optical telescope 300 years before.

Grote Reber, a radio engineer and amateur astronomer, explored Jansky's discovery further. Reber built a radio dish (a radio telescope) and "listened" to the sky during the 1930s. He discovered that the strongest radio waves came from particular places in the sky. He thought there must be some radio objects in space that were responsible for these emissions.

"Listening" to the stars through Reber's radio telescope would be like tuning a radio between channels. Reber would hear hissing static. The hiss would become louder when he tuned in to an area in space that was giving off large amounts of radio waves — the bright **radio objects.**

Bigger Radio Telescopes

Recall that the resolving power of an optical telescope relates to the fineness of detail it can image. The wavelength of the light is one factor for the resolving power — the smaller the wavelength, the better the resolving power. Radio waves have wavelengths that are millions of times longer than light waves. This means radio waves provide images with less resolution than light waves. However, radio waves penetrate dust clouds in the galaxy where visible light stops. So radio telescopes gave astronomers information about the universe that they never had before.

“Seeing” Radio Waves

You may wonder how radio astronomy produces images of radio sources. Radio telescopes cannot “see” radio sources. In the early days of professional radio astronomy, the movement of dials and needles monitored the incoming radio waves. The needle is similar to the kind you see in an ammeter or voltmeter. Astronomers then graphed the data. Today, computers store the same data and false colour it to produce images of the radio waves The colour is coded to the strength of the signal. Usually, blues are for low intensities and as the signal gets stronger, the colours go through greens, yellows, reds, and finally to whites.

Figure 5.35 The collecting dishes of the first radio telescopes were huge compared to optical telescopes. Parke’s radio telescope dish in New South Wales, Australia, is 64 m in diameter.

Optical Connections

Radio astronomers wanted to identify their strong radio sources with objects they had seen with optical telescopes. This was so they could be sure just what objects were emitting radio waves. This was impossible at first because the radio images had such low resolution. As the radio telescopes improved, astronomers could make these optical connections. For one example of an optical connection, compare Figure 5.36A and Figure 5.36B.

Figure 5.36A This is a visible light image of Centaurus A, an active radio galaxy, 16 million light-years away. (Any galaxy that emits strongly in radio waves is called an active galaxy.) You see the central nucleus of the galaxy with a lane of dust across it.

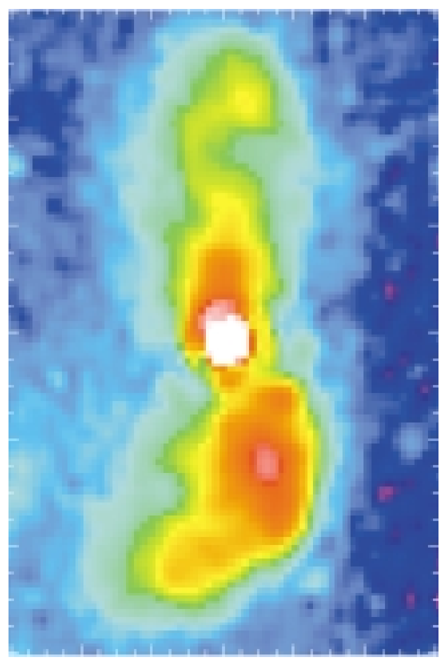

Figure 5.36B This is a radio image of Centaurus A. The telescope scanned the sky near the galaxy, and the radio waves detected were recorded in a computer. The computer then converted the strength of the signals to colours, which produced the image shown here. The visible light image covers only the white section of the central region of the radio image. The radio images show how the energy emitted from the galaxy extends beyond what we can see in visible light.

Off the Wall

The Lovell radio telescope, in Britain, was built in 1957. Radio telescopes work just as well through clouds as through clear skies, so rainy places, like Britain, are fine for radio telescopes!

Figure 5.37A The Very Large Array is a Y-shaped array of 27 identical, 25 m dishes on railroad tracks. Electric cables connect the dishes. Each of the three sections of the Y is about 20 km long. The VLA has a resolution so fine that the centimetre marks on a ruler could be seen 5 km away — if the ruler were broadcasting radio waves!

Connecting Radio Telescopes

Astronomers improved radio images by connecting telescopes. If two radio telescopes (and more recently optical telescopes) are separated by some distance, but connected electronically, their signals can be combined using a computer. The resulting images are as good as if one telescope were used that was as big as the distance between the two. This method is called **interferometry**. It's like seeing with many eyes instead of one. The most accurate set of connected telescopes in the world is the Very Large Array (VLA) in New Mexico, U.S.

Figure 5.37B A single dish from the Very Large Array.

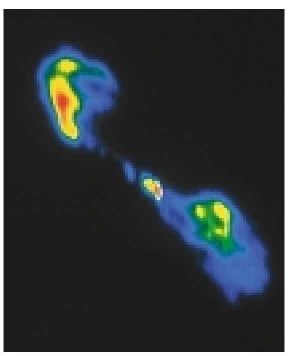

Figure 5.38 The extra resolution offered by the VLA was used to produce an image of the central white region of Figure 5.36B. The scale of this image is similar to the scale of the visible light image in Figure 5.36A. Many astronomers believe that a black hole is drawing material into it at the centre of this galaxy. The energy is given off by material before it disappears into the black hole.

Radio Telescopes Bigger Than Earth

Improvements in computers and the precision of modern clocks have enabled radio astronomers to connect their telescopes without wires. This is called **very long baseline interferometry** (VLBI). VLBI produces images 100 times as detailed as the largest optical telescopes that exist today. Astronomers combine signals from any (and as many as they want) radio telescopes in the world. Astronomers record each telescope's signal with timing marks. The signals are transferred to computer disks, loaded onto a central computer, and combined to form one image. In theory, astronomers can create a telescope as big as Earth using this technique.

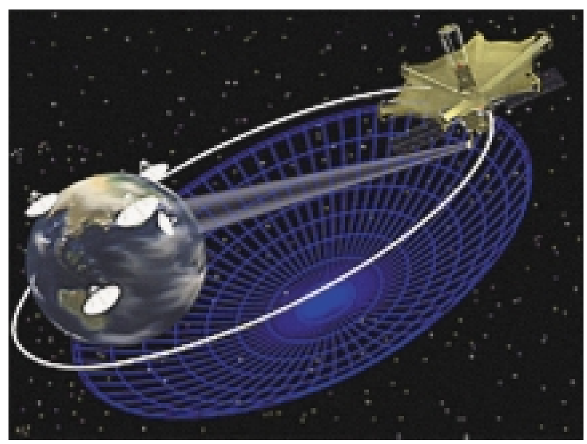

Figure 5.39 Canadian astronomers are participating in an international VLBI project called VSOP (VLBI Space Observatory Program). This project uses a radio dish in space and an array of ground-based telescopes, which simulates a single dish twice Earth's diameter! Astronomers at the University of Calgary calibrate and image some of the data for this program. This telescope has been able to image objects over 13 billion light-years from Earth.

Career CONNECT


Betsy Barton

As a child, Betsy Barton watched television astronomy shows and read all she could about astronomy. She began her career with a lifelong love for physics and math. After receiving an undergraduate degree in this area, she discovered her love for astronomy. Her Ph.D. thesis project explored galaxy interactions, and she enjoyed it so much that she has carried on this research at the National Research Council. Now, she's a professional galaxy gazer in her position as a research associate in Victoria.

Betsy is particularly interested in what happens when two galaxies come close to each other and the effects they have on one another. As galaxies near each other — that is, come less than about 150 000 light-years from one another — they can be reshaped by the other's gravitational pull. Gas from the outer edges of galaxies can then funnel to the centre, forming new stars.

This phenomenon takes place over millions of years, of course, so Betsy can't watch it happen. She can only infer that this is happening because so many galaxies that have other galaxies close by also have new stars in their centres. She has been using a group of about 500 galaxies to study the effects of galaxy interaction. To study these galaxies, she gathers optical images as well as radio observations collected by the Very Large Array telescope in New Mexico.

Are you interested in astronomy as a career?

- Talk to university or college professors to find out about careers in astronomy.
- Visit a planetarium to learn more about space.
- Conduct your own research on such topics as constellations, supernovae, galaxies, or comets and meteors.

TOPIC 5 Review

1. How did Karl Jansky know that some radio waves come from space?
2. Why are radio telescopes built so much larger than optical telescopes?
3. Explain the technique of interferometry.
4. Describe how very long base line interferometry works.
5. **Thinking Critically** If you wanted to build a radio telescope, would you build it in a country with lots of rain, sunshine, or both? Would either type of location affect the telescope's ability to make accurate observations? Explain your answer.

INTERNET CONNECT

www.mcgrawhill.ca/links/sciencefocus9

NASA has a program to develop and place telescopes into orbit that use all of the electromagnetic windows — from radio waves to gamma rays. Find out about one telescope program that is in operation. Go to the web site above, and click on Web Links to find out where to go next. Make a poster or write a brief report detailing your findings.

Wrap-up TOPICS 3-5

If you need to check an item, Topic numbers are provided in brackets below.

Key Terms

spectrum
spectroscope
spectral lines
spectroscopy
diffraction grating
spectral analysis
Doppler effect
red shifted
adaptive optics
triangulation
astronomical unit
light-year
electromagnetic radiation
radio astronomy
radio object
interferometry
very long baseline interferometry

Reviewing Key Terms

1. In your notebook, match the description in column A with the correct term in column B

A	B
• a series of closely spaced lines that splits light into a spectrum	• adaptive optics (4)
• all the various kinds of radiant energy	• Doppler effect (3)
• telescope technology that removes the effects of the atmosphere	• radio astronomy (5)
• when images from two radio telescopes are combined using a computer	• light-year (4)
• using radio waves to learn about the stars	• spectroscopy (3)
• the distance that light travels in one year	• diffraction grating (3)
• one method to measure the distance to the stars	• electromagnetic radiation (5)
• helps to measure the speed and direction of stars	• interferometry (5)
• the scientific study of spectra	• triangulation (4)

Understanding Key Concepts

2. What is a spectroscope? (3)
3. How is an emission spectrum produced? How is an absorption spectrum produced? (3)
4. How can the spectrum of a star tell us if it is approaching Earth? (3)
5. What kind of material can radio waves penetrate that light waves cannot? (5)
6. **Thinking Critically** How can larger telescopes give astronomers a more precise picture of the distances to the nearest stars? (4)
7. **Thinking Critically** Television signals are radio waves which travel at the speed of light. The first commercial TV broadcasts began about 1950. How far have these radio waves travelled in light-years? (5)
8. **Apply** In one year, light travels about 63 240 AU. Using this scale, look at the illustration and state, in light years, how far away star A is from the Sun. (4)