<table>
<tr><th>Level</th><th rowspan="2"><h1>A Radio Astronomy Design Project</h1></th></tr>
<tr><td>High school</td></tr>
<tr><th>Time Required</th><th>Lesson Summary</th></tr>
<tr><td>3.5- 50 min. class periods (175 min.)</td><td>During this lesson, students will be introduced to Radio astronomy and the telescopes which are used in the discipline. They will then be challenged to design a dish for a brand-new telescope.</td></tr>
<tr><th colspan="2">Standards</th></tr>
<tr><td></td><td>NGSS<br>HS-PS4-1 Waves and their Applications in Technologies for Information Transfer. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.<br><br>HS-PS4-5 Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.</td></tr>
<tr><th>Vocabulary</th><th>Objectives</th></tr>
<tr><td>Parabolic<br>Array<br>Interferometer<br>Focal point</td><td>• Students will understand the importance and unique aspect of radio waves.<br>• Students will understand how the Law of Reflection is used in parabolic radio telescopes.</td></tr>
<tr><th colspan="2">Materials</th></tr>
<tr><td colspan="2">• A powerful light source with a narrow, straight beam (e.g., flashlight or small LED projector)<br>• A thin sliver or segment of a curved mirror (parabolic if available, otherwise any curved mirror)<br>• A flat table surface<br>• A white receiver panel or screen (paper, white board, or cardboard)</td></tr>
</table>

- Tape and a ruler or protractor (optional, for measuring angles and focal length)
- Small flashlight with a directed beam (enough for each group)
- Small flat mirrors
- Heavy-duty aluminum foil
- Markers
- protractors
- Student computers

**Pre-Requisites**

Students should understand the electromagnetic spectrum and radio frequencies.

You should understand how a radio telescope works. See the Teacher resources section for information.

**Safety Considerations**

Students should be careful using the flashlights. They should not shine them in anyone's eyes.

**Pacing Notes**

Day 1 – Radio astronomy video, reading, project introduction, pre activity

Day 2 – Student work

Day 3 – Infographic creation

Day 4- virtual gallery walk

**Before the Lesson**

Print enough background information sheets and project sheets for each student to have one.
Make an infographic on Canva so you can help students will this task.
Get out mirrors and lasers

| Assessments | Classroom Instructions |
|---|---|
| **Pre-Activity Assessments** | **Introduction** |
| | As you are taking care of administrative tasks have students respond |

<table>
<tr>
<td></td>
<td>to this prompt.<br><br>What is Radio Astronomy?</td>
</tr>
<tr>
<th>Activity Embedded Assessments</th>
<th>Activities</th>
</tr>
<tr>
<td>Collect and grade the background information sheet.</td>
<td>1. Discussion<br>After you are finished taking attendance ask for volunteers to share their answers<br><br>2. Radio astronomy video<br>Hand out the background information sheet. This page has questions that correspond to both the video and the reading.<br><br>https://www.ted.com/talks/natasha_hurley_walker_how_radio_telescopes_show_us_unseen_galaxies?language=en (last accessed 9/12/23)<br><br>3. Radio astronomy reading<br>Students can either read this individually, in small groups, or you can read it out loud.<br>https://public.nrao.edu/telescopes/radio-telescopes/ (last accessed 9/12/23)<br><br>2 and 3 alternatives. If you would prefer to use direct instruction instead of the reading and video you may use the PowerPoint presentation.<br><br>4. Pre-activity<br>This activity will help students understand the basic concepts before designing their own telescope<br><br>1. Setup<br>Place the curved mirror flat on a table, reflective side up. Position the light source so it shines a straight, narrow beam across the surface of the mirror (i.e., at a very shallow angle).<br>2. Observation of Focus<br>behind the mirror’s surface, place the white receiver screen. Ask students to slowly move the screen back and forth to discover where the reflected light converges into the brightest point (the focal point).<br>○ Prompt: “What do you notice about where the light ends up after bouncing off the curved mirror?”<br>3. Explain Receiver Limitations<br>Have students think about the size of the receiver:</td>
</tr>
</table>

| | |
|---|---|
| | ○ If the screen is too small or misaligned, how much of the focused light do they actually collect?<br>○ How precise does the alignment need to be to capture most of the light?<br>This helps underscore the idea that in a radio telescope, you need carefully sized and placed receivers to harness the focused radio waves.<br>4. **Extension Discussion**<br>Guide a reflective discussion:<br>○ *Why does a curved mirror collect and concentrate incoming parallel light?* (Reinforce principles of reflection and focal point.)<br>○ *How might this parallel the way radio telescopes collect radio waves from distant sources?*<br>○ *What challenges arise when your receiver is too small or misaligned, and how does that limit the information you can "see"?* |
| Create a rubric and distribute on day one. | 5. Project introduction<br>a. Hand out the project sheet.<br>b. Read through the directions and go over the rubric.<br>c. Demonstrate how to create an infographic<br>It is important that the teacher has made an example of this project for themselves so they can confidently demonstrate how to use the app for the class. The Canva website (www.canva.com) is completely free for educators and students, integrates with classroom software, and will allow multiple students to collaborate on the same project if needed. Adobe Spark works similarly. |
| Walk around and ask the following questions.<br><br>What are you doing?<br><br>Why did you make that choice?<br><br>How are you helping your group?<br><br>Do you have any questions?<br><br>Can you explain that to me? | Demonstrate how the students can choose a template based on how much data they are presenting. The presentation will need a title and the name of the author(s). Images from their research can be copied and pasted into their digital design. Existing images in their template will need adjusting, or deleting. Students should resize the finished project so that it appears attractive and complete. Finally, show students where to add their works cited. Citations do not have to be visible on the main page of the presentation.<br><br>d. Either assign students to groups or allow them to select |

| | |
|---|---|
| Walk from group to group asking the following.<br><br>Do you have any questions?<br><br>Do you know how to create an infographic?<br><br>How are you dividing up the work?<br><br>Who is in charge of the citation section? | their own group. The optimal group size is three students.<br><br>6. Student research<br>a. Students should look at pictures of Radio Telescopes from across the planet<br>b. They need to select one as the model for their project.<br><br>7. Conclusion Day 1 – Telescope selection<br>Each group should identify which Radio telescope they are modeling their project on.<br><br>Day 2<br><br>1. Student inquiry work<br>Students should work in their groups on the project.<br><br>2. A diagram of the set up is available to you in this file.<br><br>Day 3<br><br>1. Student infographic creation<br>a. Students should work on their presentation.<br>b. When complete have the students add their work to the virtual space you are using for the gallery walk. |

| | |
|---|---|
| Post Activity Assessments | **Closure** |
| .Grade project according to the rubric. | **Day 4**<br>1. Virtual Gallery Walk<br>a. Use a common space such as a Google folder to host the gallery walk.<br>b. Disable students' ability to comment on their peer's work.<br>c. Have students vote for the best project.<br>d. If possible award prizes for the best projects before ending this project and moving on to the next thing. |

**Educator Resources**

National Radio Astronomy Observatory https://public.nrao.edu/
Information about radio waves from NASA
https://www.nasa.gov/directorates/heo/scan/communications/outreach/funfacts/what_are_radio_waves

Background information on Radio Telescopes

**Why the Focal Point Matters**

When light (or radio waves) comes in as **parallel rays**—like light from a distant star or galaxy—it doesn't naturally come to a point. It just keeps traveling in straight lines. A **curved mirror** (or dish) is used to **bend** those rays using reflection so that they all meet at a **single location** called the **focal point**.

**Think of it like this:**

Imagine rain falling straight down. If you place a bowl outside, all the rain that hits the bowl gets funneled to the bottom center. That's your focal point. The bowl is like a curved dish, and the rain is like incoming light or radio waves.

If you put a **receiver** or **detector** at that point—just like putting a cup under the bowl's lowest point—you can **catch all that concentrated energy** in one place. This gives you a **clearer and stronger signal**.

**Why Radio Telescopes Are Built the Way They Are**

Radio waves from space are incredibly **faint** and **spread out**. They're much longer than visible light waves and carry very little energy by the time they reach Earth.

**So, radio telescopes are built with:**

- **Large, curved dishes**: These act like the mirror in your activity, collecting as many of those weak radio waves as possible.
- **Precise shapes**: Often parabolic, so all incoming parallel radio waves reflect and converge at a single focal point.
- **Receivers at the focal point**: To "catch" the concentrated signal and turn it into data we can study.

If the telescope isn't shaped correctly, or if the receiver isn't at just the right spot, a lot of that valuable signal would be **lost**, just like moving your hand away from the bright spot created by a flashlight and curved mirror.

**Why the Focal Point Limits What You Can Collect**

- The focal point is **where all the energy gathers**, so:
  - If the receiver is **too small**, it won't catch all the waves.
  - If it's **not aligned**, it will miss the signal entirely.
- That's why radio telescope design is so precise — **even small misalignments can lose data**.

**Final Analogy: A Satellite Dish**

Think of the satellite dish on a house. It's curved to collect the signal from the satellite and reflect it all to the receiver (the small arm sticking out in front). That little receiver only works if it's **right at the focal point**. That same idea is what makes radio telescopes work.

**Acknowledgment**

The creation of the lessons in this series was funded by a generous grant from the National Science Foundation (NSF). The lessons were created as part of the SpectrumX project at the National Radio Astronomy Observatory (NRAO).

Below is a list of the lesson titles included in the series. All lessons can be accessed from this web page, https://superknova.org/educational-resources/.

**Middle School**

Introduction to Satellites
Weather Predicting
Introduction to Radio Wave Communication

The Importance of Radio Astronomy
Cubesat Model Building
Understanding FM Radio
Radio Frequency Technology
Diffraction of Radio Waves

**High School**

The Uses of Radio Waves and Frequency Allocation
Is Radio Technology Safe?
Who Decides if You Get 5G?
Measuring Sea Surface Temperatures with Satellites
Marine Animal Tracking and Bathymetry
How to Design Your Own Crystal Radio
How Radio Waves Changed the World
Simple Wireless Communication
Seeing and Hearing the Invisible
Local Wireless Radio Frequency Communication
Investigating the Internet Connection
The Geometry of Radio Astronomy

**Informal**

Modeling Radio Astronomy