

Protecting Humans from Cosmic Radiation Using Magnetic Shields

Introduction

Did you know that your phone uses light to communicate? Cell phones send and receive light waves in the **electromagnetic (EM) spectrum** to connect to cell networks, WiFi signals, and Bluetooth-enabled devices. We often think of light bulbs or the sun when we think about “light,” but in fact “light” is far more than what we can see with our own eyes. **Figure 1** shows a schematic of the different kinds of light that make up the EM spectrum.

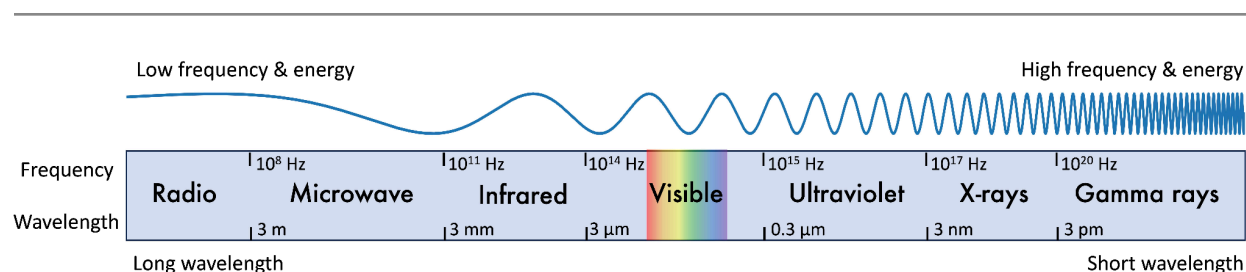


Figure 1. The electromagnetic (EM) spectrum. The spectrum of light in our universe is arranged in terms of frequency and wavelength. On the left, low-frequency, low-energy waves like the radio waves produced by your cell phone have long wavelengths of a few meters or more. On the right, super high-frequency, high-energy waves like the dangerous gamma rays emitted during nuclear explosions have tiny wavelengths of picometers (10^{-12} m) or less!

Credit: Elias Oakes

Even though we can't see most of them, all of these different forms of light surround us, constantly interacting with our bodies and environment. When EM waves interact with something, charged particles want to move in response. **Insulators** are materials where the negatively charged electrons are stuck in place, while **conductors** allow the electrons to move around freely. With the right setup, these moving particles can even create another EM wave that will block out the incoming signal. As you'll read about in the Science Bite, Earth has a handy way to block out some of the most high-energy forms of light, which helps maintain human health. If we want to go to Mars one day, however, researchers need to figure out how to keep us safe from high-energy radiation in space.

In this lesson, you'll explore these two different ways to block radiation. First, you'll build your own conductive shield that blocks out EM waves called a **Faraday cage**. Then, we'll learn about how NASA wants to use powerful magnetic fields to replicate conditions on Earth and deflect high-energy particles from space!

What To Do

Watch the Faraday cage demo and review the figure below. Then, answer the analysis questions, reading the Bite when instructed.

By wrapping a cardboard box in aluminum, your teacher just built a Faraday cage! Below is a schematic drawing of how these conductive cages can block out an applied EM field:

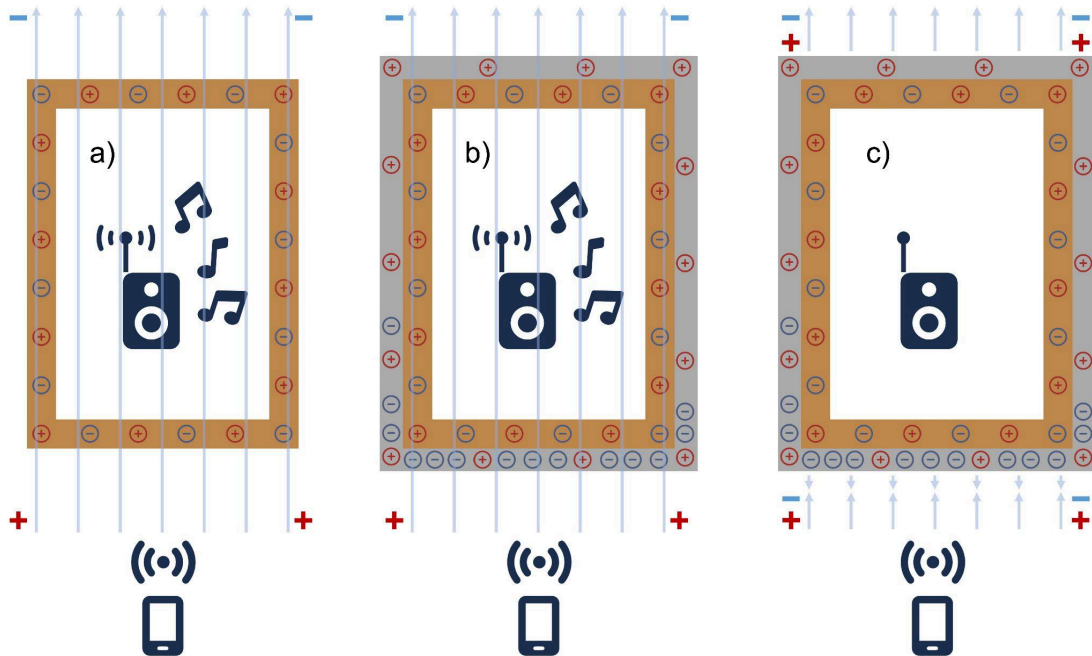


Figure 2. Schematic of a cardboard & aluminum Faraday cage.

- The cardboard has roughly equal numbers of positive protons (\oplus) and negative electrons (\ominus). The phone's bluetooth EM field passes through the cardboard, interacting with our speaker to make music play.
- When we add aluminum around the cardboard, the free electrons in the aluminum can move in response to the phone's EM field. Negative electrons are drawn to the positive side of the field (remember, opposites attract!).
- With more electrons concentrated in one place, they generate a secondary EM field that cancels out the phone's signal and stops our speaker from playing.

Credit: Elias Oakes/fontawesome.com

Analysis Questions

1. Use what you observed in the demo to fill in the following table with how the music changed at each step.

Speaker in...	Cardboard	Cardboard + plastic	Cardboard + plastic + aluminum
What happened to the music?			

2. Examine **Figure 2**. Describe, in your own words, what's happening to the phone's EM field in each panel (a, b, c). What do you notice about the phone's signal in panel (c)?

3. Think about the materials your teacher used in the demo.

Note: The plastic wrap is just there to hold everything together and prevent any gaps in our Faraday cage.

- a. Do you think cardboard is an insulator or conductor? Why?

- b. Do you think aluminum is an insulator or conductor? Why?

6. Your friend just posted the following on social media. Do you agree or disagree with their concern? Explain your answer.

Just read that phones literally use radiation to work... isn't that the same stuff that causes cancer? Should I be worried about carrying this around in my pocket? 🤔 #radiation #health

7. Think back to the Faraday cage experiment. Why do you think you lose cell reception in a closed elevator? Why do you still have cell reception in a metal car?

8. When planning their missions, NASA has to balance concerns like cost, weight and complexity against effectiveness.

a. Name one benefit and one drawback to using active magnetic shields like CREW HaT in space.

b. Why can't NASA rely on Faraday cages for their missions?

9. You see an ad online for a sun shirt that protects against ultraviolet (UV) radiation from the Sun. How do you think this shirt works? Explain your answer, considering the three different ways to block radiation that we've learned about today (Faraday cages, absorbing material, and active magnetic shielding).

- 10. Connect to the Big Question.** How did the demonstration help you “observe” EM waves, even though you can't see them? What does this tell you about how scientists can study invisible phenomena?