Sensing the World Around You

A Citizen Science Project

Activity Guide

Acknowledgments

This guide was written and edited by Valarie Bogan at NRAO (2022).

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Introduction

Welcome to the project! This citizen science project belongs to you – the people reading and participating in the research. This guide contains instructions for two activities you can do with an RTL-SDR dongle and one activity that will require some additional hardware. Try out these activities and once you have mastered them continue exploring. There are many ways to use an RTL-SDR dongle to investigate the radio frequencies around you; if you find an activity you enjoy, come back here and share it with us through the link in the Going Further section. If the activity is appropriate for general audiences and you provide detailed instructions, it may be included in future editions of this guide. At that point, you will be given credit in the acknowledgments section of the activity.

Overview of the Electromagnetic Spectrum

The electromagnetic spectrum represents all the energy that travels as a wave and radiates (moves away) from a point. This is sometimes referred to as radiation energy, but due to the negative connotations of that phrase, we will refer to it as the energy of the EM spectrum.
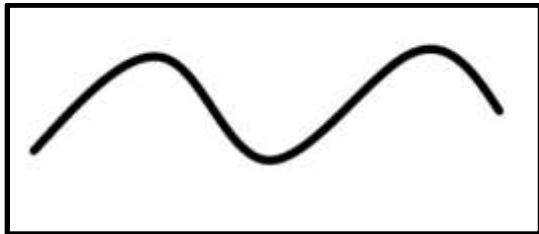
Electromagnetic Waves

Before we start talking about the different categories of the EM spectrum lets, take a moment to discuss Electromagnetic waves. All energy travels as a wave, but not all waves are created equal. For example, sound moves as a longitudinal or compression wave (Image 1). Tap a pen on the desk. Do you notice that the sound seems to move away from that point? That is because when you tap the end of your pen against the desk, it starts a vibration of the molecules. That vibration continues to move away from that point in all directions. The first vibrating molecule makes the neighboring molecules vibrate, and then those molecules make their adjacent molecules vibrate. This movement creates a wave of sound that oscillates or moves back and forth in the direction of travel.
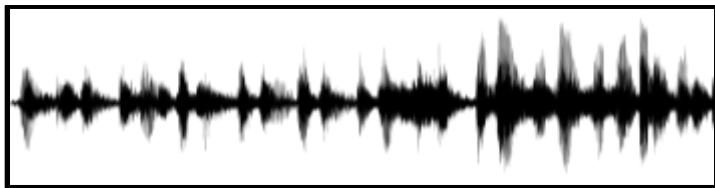
Image 1: A representation of a sound wave (Johnson, G. n.d).

Alternatively, secondary earthquake or S waves move as transverse waves (Image 2). Transverse waves also start with a vibration. However, instead of causing the molecule directly beside them to vibrate, the affected molecules cause the molecule at a 45-degree angle to vibrate. Therefore these waves move up and down at a 45-degree angle to the direction of travel.

Image 2: A representation of a transverse wave.

Both of the waves mentioned above require the movement of matter. After the vibration starts, it moves by vibrating one particle after another. Electromagnetic waves are special because they don't need there to be particles present to move from one location to another. These waves can exist and move in a vacuum which is a place completely lacking air and matter. Another thing that makes these waves unique is that they are made up of two fields; an electric field and

a magnetic field. These two fields intersect at a 90-degree angle to create a wave that looks something like Image 3.
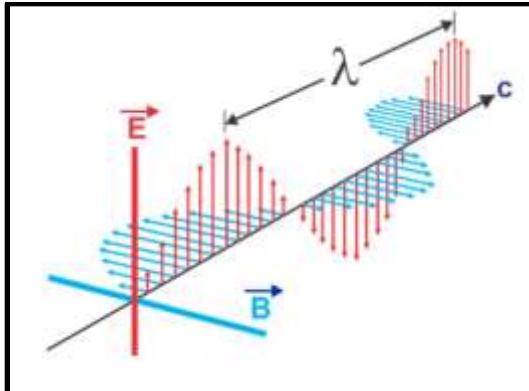
Image 3: A diagram of an electromagnetic wave (helder100, n.d.)

These waves are created in one of two ways. First, an oscillating charge can cause a changing electric field. This field then causes a changing magnetic field to form. These fields continue to cause the other to develop and travel away as an electromagnetic wave. Alternatively, an oscillating current can create a changing magnetic field. This field then causes an electric field to form, and as before, the two fields form an electromagnetic wave and move away.

Electromagnetic Spectrum

The diagram below represents all the energy included in the electromagnetic spectrum (Image 4) .
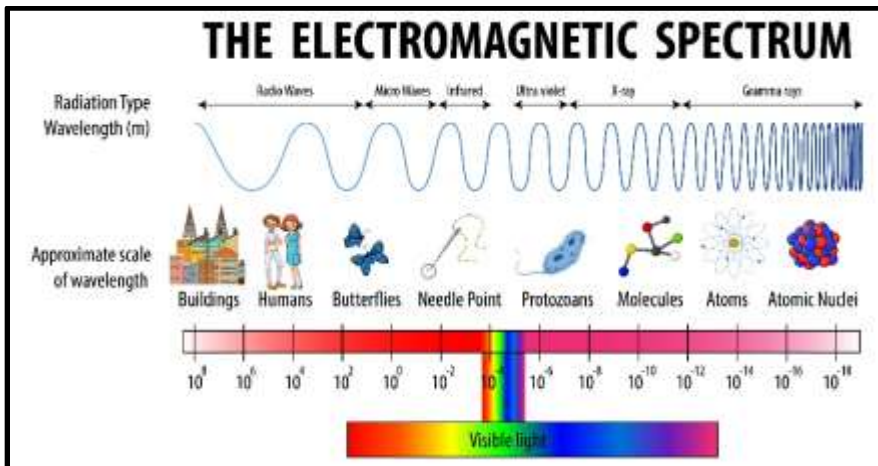
Image 4: A diagram of the EM spectrum (brgfx. (n.d).

You may recognize some of the types of energy listed in this figure, for example, visible light and x-rays. We use the energy of the Electromagnetic spectrum every day for various purposes. However, the portion of the spectrum we will use in this project may initially seem unfamiliar to you. The waves you will detect make up the radio portion of the spectrum. These are not the waves that carry music and talk to you from the radio in your car but relatively low-energy

waves that allow us to carry out many everyday tasks, such as talking on a cell phone. Begin your exploration today. Pick up your RTL-SDR and start searching the airwaves.

Activity 1: Identifying Local Broadcasters

This activity will allow you to determine who is broadcasting in your local area. To get started, follow the instructions in chapters 1-3 of the technical guide. Then get your equipment out and start scanning the spectrum in your area. The broadcasters can change depending on your location, the time of day, and even the season. So scan, scan, scan to see who is broadcasting in your area.

Be sure to upload your data to this Google form (https://forms.gle/q4fHUYC81vKNQeKf6) when you are finished scanning. No identifying information beyond a zip code is required. We want to get an idea of how many people are using the spectrum. You are welcome to upload your data as frequently as once per hour. Starting on November 7, 2022, a leaderboard will be available on the citizen science webpage (https://superknova.org/?page_id=1384). The leaders for this board are determined by the number of times a participant uploads data to our Google form. This board will be updated every Monday. So, start scanning and uploading data today!

Activity 2: Tracking Aircraft

This activity will allow you to detect the signals from aircraft traveling in your area. Your dongle can detect the signals from a plane's automatic dependent surveillance-broadcast (ADS-B) transponder. This is the same signal used by air traffic controllers to locate planes. You will learn much more than just the location of the aircraft. Through the software, you will also learn the type of aircraft traveling overhead. In addition, you will know where it took off and where it will land, allowing you to determine the flight paths that go over your area.

Complete the steps in chapters 1, 2, and 4 of the technical guide to get started. Then start scanning your skies to see what kind of aircraft are flying overhead. Please remember to upload your data to the Google form (https://forms.gle/mBvhm8JahQNjiacs9). This information will help us determine how many planes use radio frequencies at a given time. You may upload data as frequently as once per hour. Starting on November 7, 2022, there will be a leaderboard on the citizen science web page (https://superknova.org/?page_id=1384). This board will be determined by the number of times an individual uploads data concerning the ADS-B transponder. The leaderboard will be updated every Monday.

Extension Activity: Receiving Satellite Signals

This activity will probably require a better antenna than the one included with your RTL-SDR dongle. If you live in a very flat area and have fair weather, you may be able to detect a satellite with the monopole antenna if you hold it horizontally. However, you will likely have to construct a special antenna to receive a signal from a satellite. Get started by going to chapter five of the technical guide. There you will learn how to build a simple dipole antenna. If you would like to make something more sophisticated, there are a variety of other antennas you can build to detect satellites. Simply Google RTL-SDR antennas for receiving satellite signals, and you will find many web pages with directions. Once you have constructed a new antenna or decided to try the monopole antenna, be sure to follow the instructions in chapters 1, 2, and 5 of the technical guide to download and install the appropriate software.

Once you start scanning for satellites, don't forget to upload your data to the Google form (https://forms.gle/prVqpwf1uU4s6Xt7). We are interested in which satellites you can detect. You may upload data as frequently as once per hour. Starting on November 7, 2022, there will be a leaderboard on the citizen science web page (https://superknova.org/?page_id=1384). This board will be determined by the number of times an individual uploads data about receiving satellite signals. The leaderboard will be updated every Monday.

Going Further

The activities listed in this guide are intended to get you started with your RTL-SDR. However, there are so many other activities that you can do with this device. Explore. Search the internet for ideas and try them out. If you find something exciting and works well, share it with us. This is your project; it will grow through your participation. You can share your idea for a new activity through this Google form, https://forms.gle/8SPfjPXQpfpcZZ3FA.