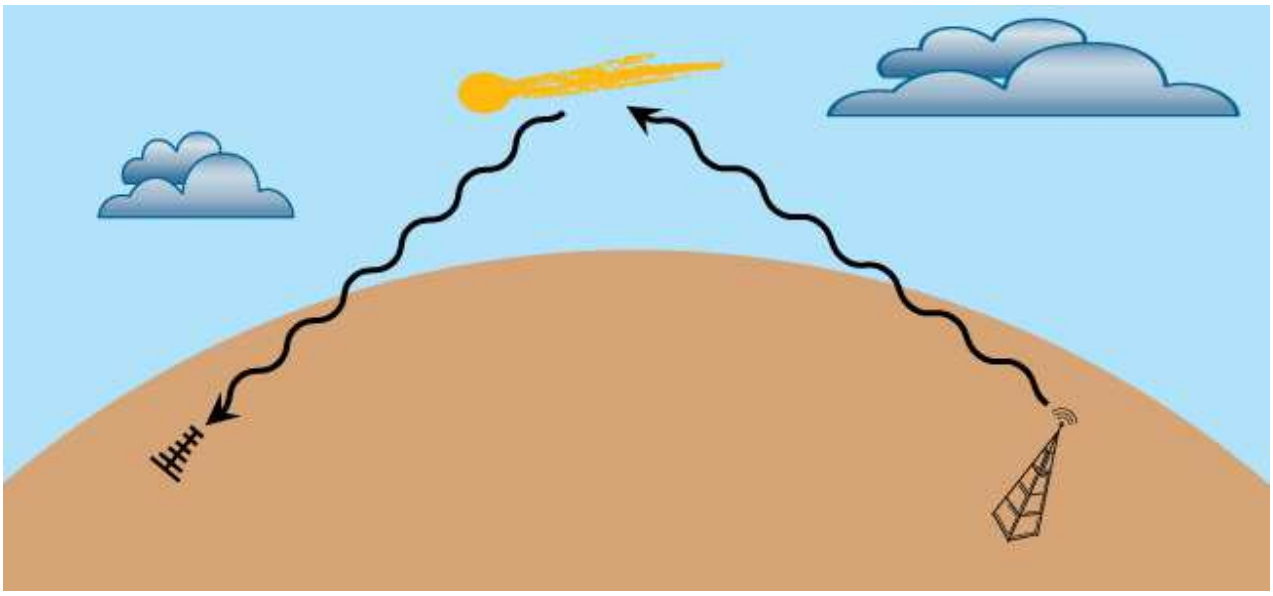
Name: _____ **School:** _____

Grade or Level: _____ **Lesson Plan #:** _____ **Date:** _____

Detecting Meteors with an FM Radio

Abstract

When a meteor burns upon entry into the atmosphere, atmospheric gases are ionized creating conditions that will reflect terrestrial radio waves that normally can only be received within the line of sight of the transmitter. Distant, over the horizon radio stations normally can not be received except when their signals are reflected back to earth from the ionized gases formed by a meteor.



By using a strong transmitter located over the horizon and a suitably tuned receiver one can detect meteors in the atmosphere.

Commercial FM radio stations (87.5 to 108 MHz) provides a very good transmitter that can be used for the detection of the ionized gases formed by a meteor. The abundance of over-the-horizon stations transmitting 24 hours a day ensures that radio detection of a meteor can be heard from a suitably positioned receiver and meteor **regardless of the time of day**.

Radio detection rates of meteors tend to be higher than visual observation rates. Meteor particles as small as 3 or 4mm can be visually seen. Meteor particles as small as 0.1mm can be detected by radio observation.

Meteor showers will provide many detections. The most intense of these is the Arietids which peak each year around June 8. They can produce up to 100 radio detections per hour.

A list of meteor showers can be found here: http://stardate.org/nightsky/meteors

Objective

In this demonstration the class will investigate meteors that enter the Earth's atmosphere. This will be accomplished utilizing a digitally tuned FM radio attached to a low cost FM Yagi antenna. The class will identify an empty frequency within the FM band of frequencies (87.5-108 MHz) where there is no kind of music or talking in daytime or nighttime. The class will then identify a FM radio transmitter that is located about 350-1,000 miles away from your location. For the best results choose a station that transmits over 30 kilowatts, and point the antenna towards this station.

What you should hear is continuous low level static until a meteor enters the atmosphere and if positioned correctly it will reflect the waves of the distant station and you will hear small segments of what is being transmitted. They sound like bumps, thumps and chirps. The longer signals you might hear pieces of music or talking. To distinguish the signals reflected from a meteors rather than others such as airplanes, the signals reflected from a meteors are very sudden, are mostly loud and clear, and fade out gradually.

The class will setup a computer monitoring system for recording these detections during unattended periods.

Introduction

Meteors or shooting stars seem like a rare occurrence only to be seen by a few lucky people that happen to looking at the right part of the sky at the right time. However, with the use of some simple and relatively inexpensive equipment, meteors can be detected and recorded as they enter the Earth's atmosphere.

Leonids Meteor Shower

Related URL's:

- http://www.space-exploratorium.com/meteors.htm
- http://stardate.org/nightsky/meteors
- http://www.radiosky.com/skypipeishere.html
- http://radio-locator.com/

Curricular Connections: (QCC/IEP/Local or National Standards):

_____

Pre-teaching for Background Knowledge

To do this student activity students should know what the following terms mean. Students should have an adult help you search the internet, or take them to a local library to find out more!

- Meteors
- Meteorite
- Meteor Showers
- FM Radio and AM Radio
- Frequency Band of FM Radio
- Yagi Antenna
- Strip Chart Recorder

Questions

1. What happens when a meteor enters the Earth's atmosphere?
2. Does the signal from an FM Radio Station curve around the Earth?
3. Can you normally hear an FM Radio Station that is 350 miles or further away?
4. What is the frequency band of FM Radio?
5. What does a Strip Chart Recorder do?
6. What is a Yagi antenna? What does it do?
7. What are meteor showers?

Materials and Equipment

Receiver:

You will need a **digitally tuned** FM receiver with an external antenna input (be sure to note what antenna impedance is required) and with a audio output jack that will be used to connect to a computer.

A used stereo receiver can be purchased very inexpensively at thrift shops, garage sales, etc. Hand held AM-FM receivers are not a good choice.

Antenna:

An easy way to solve the antenna problem is to buy a commercial FM antenna. Six element Yagi antennas can be purchased for about $25.00. These antennas will provide about 6db of forward gain over a half-wave tuned dipole antenna.

Antennacraft 6 Element FM Antenna (FM6)

Please note that the output impedance of the above antenna is 300Ω. You will need twin lead to carry the signal to your receiver. If you need to utilize 75Ω coax cabling you will need an impedance matching balun that can also be purchased at Radio Shack.

Mount your antenna with suitable mounting hardware. Run the antenna signal cable to your receiver and hook it up.

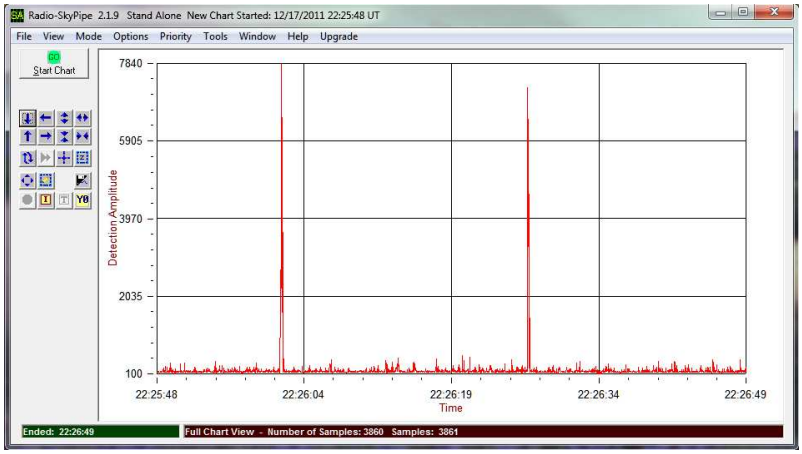
Antenna mounting hardware can be purchased at most Radio Shack stores.

Computer:

You will need a PC running Windows (98/NT/2000/Xp/Vista/win7) operating system. This computer will need a sound card that has an external audio input ("line in" jack).

Software:

You will need a Strip Chart Recorder program to capture the unpredictable output of your meteor trail reflected signal. A good free program is Radio-Skypipe II. Radio-Skypipe also has a "Pro" version that offers many features that might come in handy. The cost for this upgrade is about $50.00. This program is only available for Windows operating systems.



Experimental Procedure

The first step is to mount your antenna, run you antenna signal cable and hook it up to your receiver.

Next you will need to find a suitable transmitting FM Radio Station. Tune your radio to it's lowest FM frequency (87.5 MHz). Listen to the radio's audio output for each frequency as you tune your radio to each higher channel. When you find a channel with low noise and no station or static being received note the frequency. Continue moving up in frequency until you have 6 candidates. You need to check at night time to make sure that these frequency are clear. Find an FM radio station on the lowest clear frequency on your list that is between 350 to 1,000 miles away from your location. This station should be a high power station transmitting with 30 kilowatts or more. This website will be of help in locating a suitable station: http://radio-locator.com/. Note the compass bearing of this radio station relative to your receiving location. Rotate and lock your antenna to this compass bearing.

Next, connect the audio output of your receiver to the audio input "line in" of the sound card in your computer (you may also use the headphones output on the receiver and the mic input on the sound card/computer). You will need some audio cables and adapters to make this connection.

Download your strip chart recording software and configure it to chart the output of your sound card. Read the software's configuration instructions to do this properly.

If you are using Radio-Skypipe II, these are the steps you should take:

Under the Options tab

Identity Tab:

1. Enter your identity
2. Set your location, Latitude and Longitude in Degrees, Minutes and Seconds
3. Enter other information

Data Source Tab:

1. Select Sound Card Left or Right for source of data
2. Select Peak for Detection Method

Strip Chart Tab:

1. Set the Chart Width to your desired setting. 900 (15 minutes works well)
2. Set Y Axis to 10000
3. Uncheck Y Axis AutoScale
4. Set update chart every 1 Sample
5. Check Use Offsets and set Offset for CH 1 to 100
6. Label the X Axis - Time; Label the Y Axis Detection Amplitude

Sound Tab:

1. Select the proper device

Timing Tab:

1. Set Sample period to 10 milliseconds

Turn your radio on; start the chart and tune to a local station. You should see the chart recording various amplitudes of sound. Adjust the volume control on the radio so that the peak sounds cause the chart to just go to it's maximum scale.

Tune to remote station's frequency. You should just hear static. The chart recorder should now be recording very low level static.

Start the strip chart recorder. You are ready to start detecting and recording meteors! The best time to detect meteors is between midnight and 7 a.m., but meteors can be detected at all times of the day.

Meaningful Data Recorded

Several characteristics of meteors in the atmosphere can de derived from your data:

- The number of detected signals per hour
- The amplitude of the detected signals
- The duration of the detected signals

Project Lesson Assessment

When this project is completed the students should be able to answer these questions:

1. What happens when a meteor enters the Earth's atmosphere?
2. Does the signal from an FM Radio Station curve around the Earth?
3. Can you normally hear an FM Radio Station that is 350 miles or further away?
4. What is the frequency band of FM Radio?
5. What does a Strip Chart Recorder do?
6. What is a Yagi antenna? What does it do?
7. What are meteor showers?

Assessment Data:

	# at 30%	# at 30 to 70%	# at 70%+
What happens when a meteor enters the Earth's atmosphere?			
Does the signal from an FM Radio Station curve around the Earth?			
Can you normally hear an FM Radio Station that is 350 miles or further away?			
What is the frequency band of FM Radio?			
What does a Strip Chart Recorder do?			
What is a Yagi antenna?			
What does an antenna do?			
What are meteor showers?			

Teacher Assessment Results Summary:

Does this lesson need to be re-taught? _____YES _____NO

What portion of the lesson was most effective and why?

_____

_____

What portion of the lesson was least effective?

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What would most improve the learning of that portion of the lesson?

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What I will do to re-teach this portion:

_____

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When I teach this full lesson next time, I will:

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