



## Star Trek: MagnetoDrive -- Teacher Page



**Purpose of Star Trek: MagnetoDrive Activity:** This activity will allow students the opportunity to attempt to solve a problem, however fictional, using real astronomical equipment and data analysis. Using the scientific method, they will gather background information on a problem, create hypotheses, gather empirical data and analyze it, and finally draw conclusions and report their results.

**Materials Required:** There are some pieces of technology that will be required for optimal use of this lesson

- 1) Internet access
- 2) Microsoft Excel, or some other spreadsheet program
- 3) Microsoft Powerpoint, or some program that reads .ppt files
- 4) Contracted time on the 20m with the NRAO through SKYNET – more on this below
- 5) “Where is M13”, a free program that plots objects in a 3D view of the galaxy
- 6) Microsoft Word, or some spreadsheet program for students to write their reports

### Content Learning Outcomes:

- 1) Students will gain some understanding of the types of radiation found in astronomical objects (such as synchrotron radiation) and how it can be observed.
- 2) Students will understand how radio astronomers gather and analyze data.
- 3) Students will learn about Charles Messier and his search for comets.
- 4) Students will learn about coordinate systems, such as Right Ascension/Declination, Altitude/Azimuth, and Galactic Latitude/Longitude.
- 5) Students will learn about the structure of the galaxy and the locations of various types of objects with and around it.
- 6) Students will see the differences between optical and radio images.

### Science Education Standards (NRC, Chapter 6):

- 1) Science As Inquiry Standards (Table 6.1)
  - A. Abilities necessary to do scientific inquiry
  - B. Understanding about scientific inquiry
2. Physical Science Standards (Table 6.2)
  - A. Structure of atoms
  - B. Structure and properties of matter
  - C. Motions and forces
  - D. Interactions of energy and matter
3. Earth and Space Science Standards (Table 6.4)
  - A. Origin and evolution of the universe

## **“Unifying Concepts in Science” That Are Addressed:**

- 1) Systems, Order, and Organization
- 2) Evidence, Models, and Explanation
- 3) Constancy, Change, and Measurement
- 4) Form and Function

**Obtaining access to the NRAO/SKYNET 20m Radio Telescope:** Please download and read the relevant portions of the manual provided by the National Radio Astronomy Observatory. It outlines the procedures and contact information for teachers to use in order to gain access to this instrument.

### **Anticipatory Set:**

The story line for this lesson is based loosely upon Star Trek: The Original Series (or the recent movie). So, any activities that you use for activating prior knowledge could certainly only benefit from your use of this theme, though the theme is certainly not meant to be the learning outcome of the lesson. In some cases, it might be useful to show a clip from an episode of Star Trek so that students can better identify with the story line.

Here are some ideas for activating prior knowledge:

- 1) Have your students explore the history of comet lore and hunting over the last few hundred years, including some of Messier’s discoveries.
- 2) As a class, explore how parts of the electromagnetic spectrum are different from one another and use images to share how different wavelengths can provide us different information on an object.
- 3) Have your students role-play being astronomers at the National Radio Astronomy Observatory and explore/brainstorm the kinds of science that take place there, the science behind radio/light emissions, the construction of radio telescopes and how they work, etc.
- 4) We use radio waves in our everyday lives. Explore some of these with your students, including WiFi, cellular communication, satellite TV, microwave ovens, & AM/FM radios.

**Ideas for Extension:** There are plenty of ways in which to continue exploring the science behind radio astronomy and what it can tell us about the universe around us. Below is a short list:

- 1) Utilize some of the other lessons available from the NRAO for the 20m telescope.
- 2) Visit the NRAO in Green Bank, WV, tour the site and participate in some of the excellent education programs that are provided there.
- 3) Explore some of the science being done at other wavelengths, such as X-ray or Infrared.
- 4) Build an Itty-Bitty radio telescope (plans are available free online), or purchase one from SARA (society for Amateur Radio Astronomy), participate in Radio JOVE, INSPIRE, etc. in order to involve your students in the technology of receivers and to collect data from something that they built themselves!

**Questions or Help:** Contact Russell Kohrs (NRAO RET Summer 2012) at [rkohrs@rockingham.k12.va.us](mailto:rkohrs@rockingham.k12.va.us)

## Star Trek: MagnetoDrive

**Problem:** Stardate 1440.5, The Enterprise has been thrust far from their course by a brush with an undetected wormhole. Being unstable, this wormhole disappeared as soon as the Enterprise passed through. Navigational bearings, taken by Lt. Sulu, indicate that the crew has been thrust 33,600ly away from Earth, near M15. To make matters worse, upon entering this unknown region of space, an unknown hostile alien force immediately attacked them and while they were able to fend them off, damage to the Enterprise was extensive, including having lost warp drive and now only having two remaining days of life support. Now at full stop, Kirk, Spock, and Scotty find themselves attempting to determine the best way home. Navigation using known stars is nearly impossible, as this region is uncharted, so the positions of known stars are very different than from Earth, Impulse engines at first appear to be the only available propulsion mechanism as the dilithium crystals that powered the warp engines have fused. The situation seems hopeless, causing even stoic Nurse Chapel to faint and the doctor, Bones, to say, "Darn it Jim, I'm a doctor not a funeral director!". However, after scanning the region of space near the ship, Spock, using his typical Vulcan mental acuity to solve the problem (naturally), suggests that there may be another way to get back on course. He suggests to Kirk that they could modify the ship's nacelles to emit a magnetic field and then "star-hop" back to Earth using various synchrotron radiation sources as a series of, "to use a 20<sup>th</sup> century Earth term, Gas Stations", along the way. Despite Scotty's discomfort with replacing his beloved warp drive with some "wee little trollin' motor", Kirk decides that the modifications should move forward. However, the Enterprise is not equipped with any kind of radio telescope receiver, let alone a fancy cryogenically cooled one, so the Captain will have to rely on communication from Earth to lead them to the best synchrotron sources to aid in their journey home.

**Resources:** You are scientists at Starfleet Radio Astronomy Observatory back on Earth. You have been tasked by the Admiral of Starfleet to find good synchrotron radiation sources that the Enterprise can use to find their way home.

1) You will have access to the observatory's 20m radio telescope to conduct your research and will be limited to the objects listed below. Time is precious! You will have two frequency bands with which you may observe, 8GHz and 10GHz, with a bandwidth of 500MHz in both cases. The 20m telescope has a beam width of six arcminutes.

2) The free program "Where is M13", downloaded from <http://www.thinkastronomy.com/M13/common/download.html>

**Procedure:** In a group of four, divide up your work so that you can help the enterprise in as expedient way as possible. As it turns out, they only have 2 days of life support remaining without an influx of magnetic energy into their new experimental propulsion system. You must decide how to divide up the tasks, but they are as follows:

- A) Understand more about synchrotron radiation
- B) Understand what sort of objects are available to you in the following list
- C) Predict which objects would potentially be good synchrotron sources based upon your research
- D) Determine the distance and position of these objects relative to Earth
- E) Plot a course to Earth using these objects as sources of magnetic energy

You will have two (2) class periods to work on this, the second of which will be spent learning how to use the telescope software which you will access from school or remotely away from or in class, depending upon time.

### **Candidate Synchrotron Sources:**

#### **Potential Sources**

**M1**

**M3**

**M16**

**M13**

**M17**

**M42**

**M57**

**M58**

**M59**

**M60**

**M87**

**M89**

**M92**

**M101**

**M12**

#### **Step 1: Questions for background research before starting:**

- 1) What is synchrotron radiation?
- 2) List some of the properties of synchrotron radiation.
- 3) What kinds of astronomical objects produce synchrotron radiation?
- 4) In what part of the electromagnetic spectrum are the frequencies of 8GHz and 10GHz located?
- 5) How will you determine noise from a signal?
- 6) At which frequency will synchrotron sources be stronger, 8GHz or 10GHz?
- 7) What are Messier Objects and who was Charles Messier?
- 8) Which Messier Objects are candidate sources?
- 9) How far away from Earth are the sources in your list?
- 10) When can you view the sources in your list from your location (school or home)?
- 11) How does a beam width of six arcminutes affect your survey data's resolution?
- 12) What is a Jansky, and what can that unit tell you about the object?
- 13) Where in the galaxy is M15 and how do I get them home?
- 14) Is magnetic propulsion even possible?

## Step 2: Observations and Data Collection

**Create Hypothesis(es):** Create a hypotheses, or multiple working hypotheses, as a prediction of the outcome of your observations based upon your background research. Write it below:

### Take Observations

It's now time to use the telescope! You will be using a 'daisy' scan to observe the objects. It's called a daisy scan because the telescope moves in a pattern that looks like daisy petals. Remember the telescope is as tall as a 6 story building and we use a daisy pattern to minimize the wear and tear on the telescope. We wouldn't want a 6 story building wildly swinging back and forth.

You should use the SKYNET interface to conduct your observations as your objects will be available at different times of the day and night. Follow the instructions in the manual for the 20m that can be downloaded from the 20m website.

Objects I will observe:

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**Gather Your Data:** You can freely download your data from [www.gb.nrao.edu/20m/peak/log.htm](http://www.gb.nrao.edu/20m/peak/log.htm) Find it using the scan number in the name of the link along with the Messier number. Use the 2D and 3D plots to help you answer these questions:

- 1) Which objects clearly show radio brightness?
  
- 2) Which objects don't appear to have strong radio signal?
  
- 3) Which objects are hard to classify as a strong or weak source? Why?





### **Step 3: Data Analysis**

First you'll want to figure out what you just observed!

- 1) Compare the graphs on the website with the visual images in the PP. What do you notice?
  
- 2) Why are some objects brighter in the radio spectrum than others?
  
- 3) Synchrotron sources are typically brighter at lower frequencies than they are at higher frequencies. Do you see any objects that display such a pattern? Create a simple table in Excel that lists your objects and their brightness in Janskys (see extension section for how to convert intensities to Janskys) for each frequency. This table should be imported into the "Observations and Data Collection" portion of your report.
  
- 4) Using the program, "Where is M13", plot all of the Messier Objects on the galaxy. Where do these different objects reside with respect to the galaxy? Hint: You will have to zoom in and out (sometimes WAY out) to see them all!

Star Clusters:

Galaxies:

Nebulae:

Globular Star Clusters:

- 5) Uncheck all the Messier Objects except your synchrotron sources. Given the Enterprise's current location, list the sources to use as "gas stations" in the order in which the crew should travel to them.

### **Step 4: Report Your Findings to Starfleet**

Report your findings to Starfleet in the form of a written paper. It should have several sections: Abstract, Introduction, Background Research, Observations and Data Collection, Data Analysis, and Conclusions (you may call it something like "recommendations" if you would like. Your paper should be at least two (2) typed pages, double-spaced, 12 point Cambria or times New Roman font with no more than 1' margins. When complete, turn your report into the admiral (your teacher) for consideration.



## Extension:

In the data analysis, your teacher may prefer that you import ASCII data into Excel and convert the given left and right intensities (in counts) to kelvins or Janskys.

To convert to Kelvin:

1) The intensities in the ASCII file are total intensities, meaning the object intensity and the system intensity. You need to subtract the system values for the left and right polarizations (which can be found in the corner of the 2D plot) and then use the following conversion factors that can be found in an Excel table on the website.

To convert to Janskys:

Use the following equation (re-arrange as necessary):

$$S = \frac{2\sigma T_A}{A\eta_A}$$

Where:

S = Flux Density (Janskys)

$\sigma$  = Stefan-Boltzman constant ( $1.38 \times 10^{-23}$ )

$T_A$  = Average temperature (Left, Right polarization, in K)

$\eta_A$  = Telescope Efficiency (elevation dependent, available on website)

A = Area of dish (available on website)