Chapter 15: Decoding the Pulsar Map

Student Worksheet

Objective:

Find the 14 pulsars included on the pulsar map on board the Voyager spacecrafts and the Pioneer 10 and 11 spacecrafts.

Engage:

The map you are to decode is engraved on a golden record at the outer limit of our solar system. The record contains diagrams and images for understanding the species of people who sent the spacecrafts out into the cosmos, as well as recordings of greetings in several languages, and a variety of music from various time periods and corners of the world.

If you were tasked with creating a golden record to be intercepted by alien life, what are 5 things you would put on there and why?

Introduction:

The pulsar map is designed to show any intelligent extraterrestrial life the location of Earth based on the locations of 14 pulsars. Knowing even a few of the 14 pulsars would give enough information to triangulate the position of Earth. Since extraterrestrials are expected to read the map, you should be too!

Pulsars are a special kind of neutron star. The spin very quickly, regularly, and the periods of their rotations are unique enough to be used as a form of pulsar identification. Measuring the period of the pulses gives a lot of information about the pulsar. In general, the more massive the pulsar, the slower it spins.

The pulsars on the map are listed according to their period of rotation. They are listed in *binary code*, a base 2 number system in which every number can be represented as a zero

or a one. In the pulsar map you will see dashes in the place of zeroes. We cannot assume extraterrestrial life would use a base ten number system; so, binary, being the simplest number system, was the best choice for listing the pulsars.

Figure 1 below shows the pulsar map:

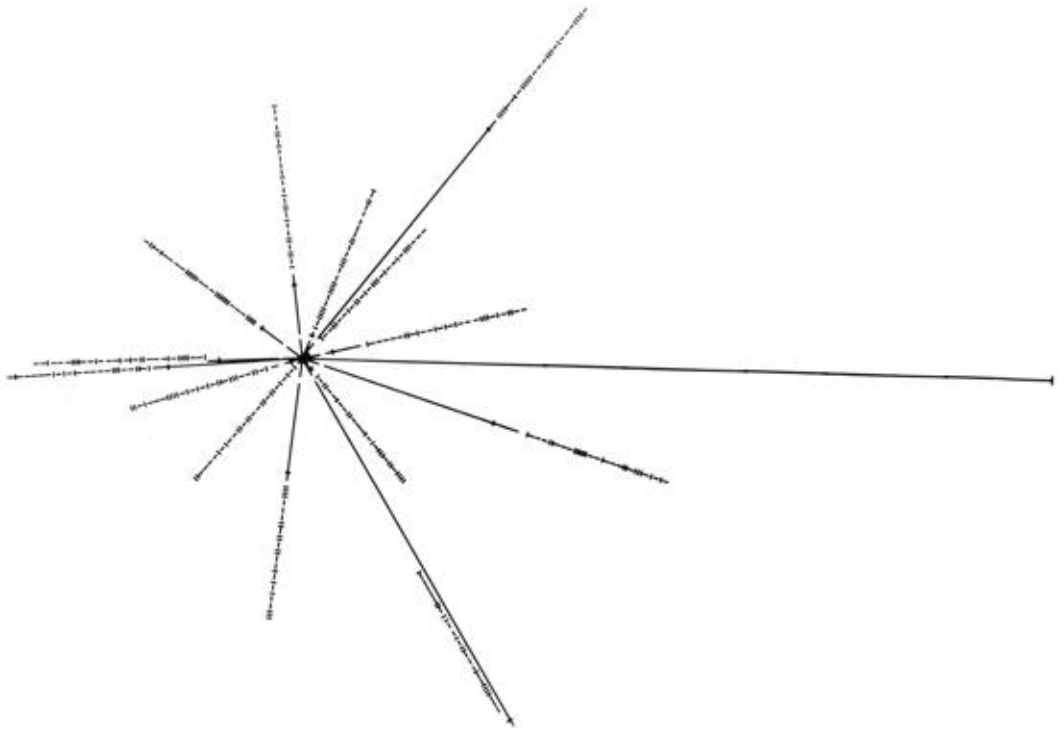

Figure 1 Pulsar Map NASA/JPL

The long line, without any dashes at the end, points to the center of the Milky Way. The lines converge at the Earth. The length of the lines represents the distance to the pulsar. At the end of each line there is a long binary code representing the period of the pulsar in units of hydrogen transitions.

Your Task:

Decode the numbered pulsar map which your teacher will provide.

Procedure:

1. Decode the binary numbers for each of the 14 pulsars. Write the base ten numbers in Table 1 below in the column labeled *Period in Base 10*.

Table 1 Binary code from NASA Pulsar Map

Pulsar Number	Binary	Period in Base 10	Period in Seconds	Pulsar Name
1	10001100011111001000011011101010			
2	10110010011000101011101101111			
3	10000011011001011000100111000			
4	11110001101101100101010011			
5	10101011011001101100101000011			
6	10110011101101010101111000101 1			
7	10110011100000101010000010			
8	10011110100011010100010011100 0100			
9	11110001111110001111100001011 0			
10	10110110010110100100001011000 1			
11	10111100111100111001100000110 1			
12	11110010111110001110100011110			
13	10011001011010111010010111000			
14	10000011010010101000111010110 0			

2. The unit for time in the pulsar map is in terms of the frequency of a photon emitted by a hydrogen atom when its electron and proton move to a state of opposite spins. This is symbolized in the two circles shown on the map and has a frequency of 1420 MHz, or 1/1,420,000,000 = 7.04225353 x 10^{-10} seconds. Remember period equals one divided by the frequency, or T= 1/f.
    a. Multiply each value in the Base Ten column by 7.04225353 x 10^{-10} seconds to get the period of each pulsar in seconds. Record all of the given digits; do not round.
    b. Record these values in the column of Table 1 labeled *Period in Seconds*.

3. Now, match the period of your pulsar in seconds to the name of the pulsar. In order to obtain the pulsar names, follow the instructions from your teacher about how to set up a search in the online pulsar catalog. Record the names in the column titled *Pulsar Name*.

Conclusion:

1. In your opinion, what are the benefits and limitations of the binary number system?

2. Pulsar 12 has a period of about 0.3587 seconds. What is the frequency of this pulsar?

3. What information would you need to locate these pulsars in space?

4. Why is the transition of energy states of hydrogen a good way to represent time?

Extend:

- Explore the Voyager and Pioneer missions further. NASA's mission pages are a great resource.

- See and hear the Golden Record. The Voyager mission page at NASA will take you there.