Arecibo Message Pixel Puzzle - teachers' notes

The Arecibo message was sent into space by a radio wave at a very high frequency. The image was transmitted as a series of frequency modulations with the frequency shifting slightly up to transmit the equivalent of a binary '1' and the frequency shifting slightly down to transmit the equivalent of a binary '0'.

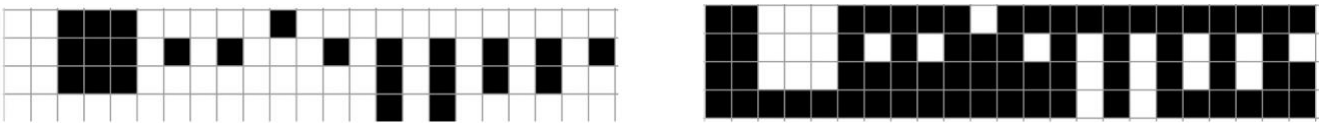
In total 1,679 'bits' of data ("1"s and "0"s) were sent like this, which is an unusual number. You might think that some data is missing and that it should be rounded up to 1,680 but 1,679 is a semi-prime, the product of two prime integers - 23 and 73.

This number was chosen with the idea that an intelligent life-form could spot that the information should be displayed as a grid of either 23 x 73 or 73 x 23, and only one of these 'looks right'. The full message becomes visible if chunked into 23 columns and 73 rows. This pixel puzzle is an excerpt from the full picture, displaying 15 lines of the 73 line message.

If you were to listen to an audible version of the message and write down a "1" every time you heard a high pitch and a "0" every time you heard a lower pitch you would end up with a string of digits looking like this - 0 0 1 1 1 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 1 0 1 0 1 0 0 0 1 0 1 0 1 0 1 0 1 0 1 0 0 1 1 1 0 0 0 0 0 0 0 0 1 0 1 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 1 0 1 0 0 0 0 0 0 0 0 1 0 1 1 0 0 0 0 0 1 1 0 0 1 1 0 0 0 0 0 0 1 1 0 0 1 1 0 0 0 1 0 0 0 1 0 1 0 0 0 0 0 1 0 1 0 0 0 1 0 0 0 0 1 0 0 0 1 0 0 1 0 0 0 1 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 1 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0.

There are 345 digits in that string and to view the intended image correctly you'd need to re-arrange the digits into 23 columns and 15 rows. It would certainly help to do this on squared paper and to colour the 1s in black (note that you could also colour all the 0s black and have the image show as white). A 345 character message could also be rearranged into a 5 x 69 or 115 x 3 grid which wouldn't show an image, but there's less ambiguity with a 1,679 bit message.

Here are four lines of the message coloured in to make the image clearer.



The same information - but with the 1s coloured black & the 0s white in the left (reversed on the right).

Listen and decode

You and your class can try listening to an audible version of part of the message.

- Make sure everyone has paper and pencil (ideally a small piece of squared paper with 23 squares in a line - you can print free squared paper with 29 squares in a row, (https://print-graph-paper.com/details/1-4-inch/a4) or choose your preferred style here https://print-graph-paper.com/
- Go to **https://cs4fn.blog/arecibo** and scroll down to **3. Sound files**

- Tell the class that they will hear an audio clip made of two tones, a higher one and a lower one. When they hear the higher one they should write down the number 1 and for the lower tone they should write 0. They need to write the numbers on the same line (graph paper can help ensure this!).
- Play **1. Test tones for practice** so that everyone can hear the difference between the higher and lower tone, they don't need to write anything for this bit
- Play one of the four **2. Arecibo Message – Line 58 at different speeds** files. Each contains the same information (Line 58 of the Arecibo Message) but there are four different speeds. Ask the class to write down 1 for the high note and 0 for the low note then see if anyone was able to transcribe it. The string is below (gaps added to make it easier to read)

00111 0101 000 1010 1010 101

Probably the first and fastest of the four files was difficult to keep up with. It transmits the information at a rate of around 2 bits per second (23 bits in an 11 second sound file). The second (medium pace) transmits at about 1.5 bits per second, the third is closer to 1 bit per second and the last (slowest) file is a bit less at about 0.8 bits per second and much easier to keep up with.

The original Arecibo message was transmitted in a fairly similar way but quite a bit faster, at 10 bits per second - there were 1,679 bits, so the whole message took about 3 minutes to send.

1,679 bits at 10 bits per second takes about 170 seconds which is a little under three minutes.

Although the actual message sent into space wasn't audible to human ears as it was sent at a frequency that is too high for our ears to hear the people at the Arecibo telescope also created a version that is audible, which you can listen to on the Sound files page (**3. An audible version of the Arecibo Message**).