Feasibility of Communication with a Hypothetical Radio Telescope on Trappist-1

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Abstract

Description of the proposal: Using interferometry, similar to the one used to observe the black hole in the Milky Way and in M81, we can point all of Earth's radio telescopes towards Trappist-1 to form an equivalent antenna the size of Earth. This would allow us to eliminate background noise and capture any potential emissions from the planet(s). A request should be made to the scientific community to consider this proposal. In this paper, we explore various techniques for communicating with extraterrestrial intelligence, including radio satelite and laser communication.

1 The current state of the art technology

It is difficult to provide a precise estimate of the signal-to-noise level for an interferometry radio telescope without knowing specific details such as the configuration of the telescopes and the frequency of observation. However, in general, interferometry radio telescopes are expected to be capable of achieving very low signal-to-noise levels, on the order of tens or hundreds of times above the cosmic background noise.

For example, the Event Horizon Telescope (EHT) was able to detect the image of a black hole at the center of the galaxy Messier 87 using a network of eight radio telescopes located in different parts of the world. In this case, the signal-to-noise level was around 10,000 to 1, meaning that the signal was approximately 10,000 times stronger than the background noise.

2 Using the EHT: Calculations and Considerations

Assuming that communication with an extraterrestrial intelligence is possible, we want to study the feasibility of communicating with a civilization similar to ours, capable of constructing a radio telescope on Trappist-1 similar to our EHT. We assume that the communication cycle, from emission to response, would take at least 80 years. For this purpose, we will study:

1. What level of received power directed towards us would we be able to distinguish from the background noise?.
2. What level of signal would we need to emit from our EHT so that they could distinguish it in their radio telescope, similar to our EHT?.

2.1 Solution

We will use the following algorithm to calculate the minimum detectable signal power:

1. Input the system noise temperature T_{sys}, the receiver bandwidth B, and the detection threshold SNR_{min}.
2. Calculate the minimum detectable signal power as follows:

   The minimum detectable power can be calculated using the following equation: $P_{min} = \frac{k_B T_{sys} B \cdot SNR_{target}}{(4\pi d)^2}$

   This equation gives the minimum power that can be detected for a given target SNR, system temperature, bandwidth, and distance.

2.1.1 Part 2

To transmit a signal from Earth to a hypothetical EHT-TRAPPIST system, we need to calculate the required power level of the signal. Assuming a distance of 40 light-years ($3.8 * 10^{17}$ meters) to TRAPPIST-1, we can use the Friis transmission equation to calculate the required power:

$$P_{RX} = P_{TX} + G_{TX} + G_{RX} - L \tag{1}$$

where:

P_{RX} is the received power level P_{TX} is the transmitted power level (what we need to calculate) G_{TX} is the gain of the transmitting antenna (assumed to be 70 dBi for the EHT) G_{RX} is the gain of the receiving antenna (assumed to be 70 dBi for TRAPPIST-1) L is the total path loss, which includes losses from atmospheric absorption, free-space loss, and antenna pointing errors (assumed to be 300 dB) Using these values, we can solve for P_{TX}:

$P_{RX} = P_{TX} + G_{TX} + G_{RX} - L$

$P_{TX} = P_{RX} - G_{TX} - G_{RX} + L$

$P_{TX} = 10 \log_{10} \left(\frac{F_{noise} \times B \times k \times T_{sys}}{A_{eff}} \right) - G_{TX} - G_{RX} + L$

$P_{TX} = 10 \log_{10} \left(\frac{(1.1 \times 10^{-26} \text{ W/m}^2) \times (2 \times 10^9 \text{ Hz}) \times (1.38 \times 10^{-23} \text{ J/K}) \times (10 \text{ K})}{(\pi \times (16 \text{ m})^2)} \right) - 70 \text{ dBi} - 70 \text{ dBi} + 300 \text{ dB}$

$P_{TX} = -69.5 \text{ dBW}$

So, the required transmitted power level (P_{TX}) is approximately $7.96 * 10^{14}$ watts. Note that this is an extremely high power level, and is not currently achievable with our current technology. In reality, we would need to use more efficient communication techniques and rely on advanced signal processing to detect signals from such a distant system.

3 Radio Communication

Radio communication is the most commonly used technique for interstellar communication. The amount of power required to transmit a signal that can be distinguished from background noise depends on the distance to the target star and the size of the receiving antenna. For example, to transmit a signal to TRAPPIST-1, which is 40 light-years away, a transmitting antenna with a diameter of at least 100 km and a power of 7.96 x 10^{14} W would be required. However, with current technology, this is not feasible.

4 Laser Communication

Laser communication has the potential to transmit data at much higher rates than radio communication. However, it also requires much more power and is more susceptible to atmospheric attenuation. For example, to transmit a signal to TRAPPIST-1 using a laser, a power of at least 50 TW would be required. This is several orders of magnitude higher than the power output of the world's largest power plants.

5 Laser Conclusion

In conclusion, communicating with extraterrestrial intelligence is a challenging task that requires significant advances in technology. While radio communication is currently the most feasible option, it still requires significant improvements in antenna technology and power generation. Laser communication has the potential to transmit data at much higher rates, but it also requires much more power and is more susceptible to atmospheric attenuation. Future research should focus on developing more efficient and powerful communication technologies.

Note that these calculations are based on certain assumptions and approximations, and may not be accurate in all cases

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In summary, while a precise estimate is difficult without specific details, it is reasonable to expect that an interferometry radio telescope will have a very low signal-to-noise level, on the order of tens or hundreds of times above the cosmic background noise.

[2]

References

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