Radio power comparison Tsar Bomba (1961) vs. Arecibo SETI Signal (1974)

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1 Introduction

In 1974, the strongest intentional radio signal ever was sent into space by humans from the Arecibo radio dish in Puerto Rico. It's strength was an impressive 20 trillion watts. This is enough electricity to power 1.4 million homes for one year. The Arecibo signal's objective was to contact extraterrestrial intelligence. However, 12 years earlier, a considerably stronger radio signal was sent from Earth. The nuclear Russian Tsar Bomba burst in 1962 delivered 5.3 yotta watts of energy. (That bomb was not intended to contact ET, but rather to intimidate the United States). Was the radio power from the Tsar Bomba more powerful than the Arecibo message?

Considerations 5% of the power of a nuclear explosion are emitted as radio waves. At a height of approximately 3,962.4 meters, the height of the Tsar Bomba explosion, a significant portion of electromagnetic radiation, including gamma rays, X-rays, and ultraviolet rays, is released into space. The exact percentage can vary, but it is estimated that about **70-80%** of the electromagnetic radiation would escape into space, as the atmosphere at this altitude is thin enough to allow much of the radiation to pass through.

Given Data - Total power of Tsar Bomba: $P_{Tsar} = 5.3\,yottawatts = 5.3 \times 10^{24}\,watts$ - Percentage of power released as radio energy: $5\% = 0.05$ - Power of the Arecibo signal: $P_{Arecibo} = 20\,trillionwatts = 20 \times 10^{12}\,watts$ - Estimated percentage of electromagnetic radiation that escapes into space: we assume an average of $75\% = 0.75$

To calculate the strength of the Tsar Bomba's radio emissions compared to the Arecibo signal, we follow these steps:

1. Calculate the total power emitted by the Tsar Bomba as radio waves. 2. Adjust for atmospheric effects based on the percentage of emissions that escape

into space. 3. Compare the adjusted power of the Tsar Bomba's radio emissions to the power of the Arecibo signal.

Step 1: Calculate the Radio Power of Tsar Bomba First, calculate the power emitted as radio waves:

$$P_{radioTsar} = P_{Tsar} \times 0.05$$

Substituting in the values:

$$P_{radioTsar} = (5.3 \times 10^{24} \, watts) \times 0.05 = 2.65 \times 10^{23} \, watts$$

Step 2: Adjust for Atmospheric Effects Next, apply the estimated escape percentage to find the effective radio power that reaches space:

$$P_{escapedTsar} = P_{radioTsar} \times 0.75$$

Substituting in the values:

$$P_{escapedTsar} = (2.65 \times 10^{23} \, watts) \times 0.75 = 1.9875 \times 10^{23} \, watts$$

Step 3: Compare with Arecibo Signal

Finally, we compute how many times more powerful the Tsar Bomba's escaped radio emissions are compared to the Arecibo signal:

$$StrengthRatio = \frac{P_{escapedTsar}}{P_{Arecibo}}$$

Substituting in the values:

$$StrengthRatio = \frac{1.9875 \times 10^{23} \, watts}{20 \times 10^{12} \, watts} = \frac{1.9875 \times 10^{23}}{2 \times 10^{13}} = 9.9375 \times 10^9$$

Final Result The Tsar Bomba emitted a signal approximately 9.94 billion times stronger than the Arecibo signal in terms of radio emissions after considering atmospheric effects. To determine the difference in orders of magnitude between the Tsar Bomba's escaped radio emissions and the Arecibo signal, we can use the power values calculated previously:

$$DifferenceinOrdersofMagnitude = \log_{10}(P_{escapedTsar}) - \log_{10}(P_{Arecibo})$$

$$\approx 23.2988 - 13.3010 \approx 9.9978$$

Conclusion The difference in orders of magnitude between the Tsar Bomba's escaped radio emissions and the Arecibo signal is approximately 10 orders of magnitude. This means that the Tsar Bomba's radio emissions are about 10^{10} times stronger than the Arecibo signal or **ten billion times** stronger.

Addendum:

But, wait you say **ARECIBO send a targeted message towards Hercules**

Let's now take into account that the Arecibo dish sent out a concentrated radio signal, not just showering the sky at random with radio waves like a nuclear explosion does. The radio power from Arecibo was directed towards the region of Hercules.

The Hercules cluster is quite expansive and covers about **3%** of the visible sky and this is the same as the total sky. If we adjust the power output from the Tsar Bomba to 3% we get the following result:

10 billion x 0.03 = 300 million

So, all in all, the Tsar Bomba emitted 300 million times more radio power towards Hercules than Arecibo. Now, let's consider for one second that this **Tsar Bomba nuclear explosion sprayed the entire sky with a radio signal 300 million times more powerful than Arecibo**... and consider that 2000 further explosions lit up Earth from 1945 until 1962.

Do you think there is a small chance that this may have been noticed by extraterrestrial intelligences, if they exist? Apparently the Arecibo message was never meant to actually contact ETi, it was only a technology demonstration.