TSAR Bomba Nuclear EMP detectability by Extraterrestrial Civilization

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The detectability of the Tsar Bomba's electromagnetic pulse (EMP) in space would be significantly greater than that of other nuclear explosions due to its immense power. According to the provided information, the Tsar Bomba's escaped radio emissions had an effective power of approximately 1.9875×10^{23} watts. For comparison, the Arecibo message, a deliberate interstellar transmission, had a power of 20 trillion watts (20×10^{12} watts). This makes the Tsar Bomba's EMP nearly 10 billion times more powerful than the Arecibo message

in terms of total radiated radio power.

To estimate the observability distance, we can use a similar approach to that for other high-altitude nuclear EMPs, assuming the peak radio emission is concentrated around 100 MHz, a typical frequency for such events.

1. Estimated Peak Isotropic Spectral Luminosity ($L_{iso,\nu}$): Assuming a representative bandwidth of 100 MHz ($10^8 Hz$) for the peak emission: $L_{iso,\nu} = \frac{P_{escapedTsar}}{\Delta\nu} = \frac{1.9875\times10^{23}W}{10^8 Hz} = 1.9875 \times 10^{15} W/Hz$

2. ETI Receiver Sensitivity Benchmarks: We consider the same levels of ETI technological advancement as in previous analyses: Earth-Equivalent (SKA2 Sensitivity): $S_{min} = 0.13Jy = 0.13\times10^{-26} W m^{-2} Hz^{-1}$**.[7] Advanced ETI (100x SKA2 Sensitivity):** $S_{min} = 0.0013Jy$**. Highly Advanced ETI (1000x SKA2 Sensitivity):** $S_{min} = 0.00013Jy$**.**

3. Estimated Observability Distances: Using the link budget formula $r = \sqrt{\frac{L_{iso,\nu}}{4\pi S_{min}}}$**:**

4. Earth-Equivalent ETI (SKA2 Sensitivity): $r = \sqrt{\frac{1.9875\times10^{15} W/Hz}{4\pi\times(0.13\times10^{-26} W/m^2/Hz)}} \approx 3.488 \times 10^{20} m$ **Converting to light-years** ($1ly \approx 9.461 \times 10^{15} m$)**:** $r \approx$ **36,866 light-years**

5. Advanced ETI (100x SKA2 Sensitivity): With a 100-fold improvement in sensitivity, the range increases by a factor of $\sqrt{100} = 10$**.** $r \approx 36,866ly \times 10 =$ **368,660 light-years**

6. Highly Advanced ETI (1000x SKA2 Sensitivity): With a 1000-fold improvement in sensitivity, the range increases by a factor of $\sqrt{1000} \approx 31.62$**.** $r \approx 36,866ly \times 31.62 \approx$ **1,165,800 light-years (or approximately 1.17 million light-years).**

Implications and Caveats:

These calculations suggest that the Tsar Bomba's EMP, given its extraordinary power, could theoretically be detectable across vast interstellar distances, potentially reaching well into other galaxies for highly advanced ETI. This is a significantly larger range than that estimated for the Starfish Prime test (which was in the tens to hundreds of light-years range).