Feasibility of Detecting Alien Signals[1]

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Let us assume that the aliens are no more than 11 light years away. The question we would like to answer is the following: *How much energy must the aliens expend to have a reasonable chance of contacting us?* Also, let's assume they aren't deliberately trying to contact us so that the beam isn't focussed towards earth. Now, let's get some useful units.

$$\begin{aligned} 1\,ly &= 9.45 \times 10^{15}\,m \\ 11\,ly &= 1.04 \times 10^{17}\,m. \end{aligned} \tag{1}$$

11 light years is a nice number (Sirius is about that far), if the aliens are closer the stats will be even better. It isn't hard to convert these calculations to another distance. The intensity of the radiation is given by the Poynting vector. Let's assume a dipole source so the intensity is given by

$$\langle \mathbf{S} \rangle = \left(\frac{\mu_0 p_0^2 \omega^4}{32\pi^2 c} \right) \frac{\sin^2\theta}{r^2} \hat{\mathbf{r}} \ \ \mathrm{W/m^2} \tag{2}$$

where p_0 is the maximum dipole moment. Notice that expression (2) has a maximum at $\theta = \pi/2$. Let us therefore assume the best case scenario when the transmitter is oriented in such a way that Earth is at this value of θ.

$$\langle \mathbf{S} \rangle = \left(\frac{\mu_0 p_0^2 \omega^4}{32\pi^2 c} \right) \frac{1}{r^2} \hat{\mathbf{r}} \ \ \mathrm{W/m^2}. \tag{3}$$

Now, some WEB surfing at NASA has revealed that a 34 m diameter dish can detect a signal strength of 2.5×10^{-18} Watts (this is surprising ain't it?). Let's find out what kind of intensity this corresponds to

$$\begin{aligned} \text{Intensity} &= \frac{\text{power}}{\text{meter}^2} \\ \langle \mathbf{S} \rangle &= \frac{2.5 \times 10^{-18}}{\pi \left(\frac{34}{2}\right)^2} \\ &= 2.75 \times 10^{-21} \mathrm{W/m^2}, \end{aligned} \tag{4}$$

[2]Please note: this is a very quick "back-of-the-envelope" type calculation.

i.e. this is what we can detect. Sticking this value of $\langle \mathbf{S} \rangle$ into (3) yields the following:

$$p_0^2 = \frac{32\pi^2 c r^2 \, 2.75 \times 10^{-21}}{\mu_0 \omega^4}. \tag{5}$$

We now know what p_0 is needed to detect a signal here on Earth, r is given by (1). The total power radiated is given via integration of (2) over a sphere.

$$\langle P \rangle = \frac{1}{4\pi\epsilon_0} \frac{p_0^2 \omega^4}{3c^3}. \tag{6}$$

Inserting all the values gives us the amount of power that must be emitted by the aliens:

$$\langle P \rangle = \frac{8}{3}\pi \left(1.04 \times 10^{17}\right)^2 \, 2.75 \times 10^{-21} = 2.49 \times 10^{14} \;\; \text{J/s}. \tag{7}$$

Let's convert this to some nifty units. A fairly large hydrogen bomb has an energy yield of about 20 megatons of TNT and one ton of TNT releases about 4×10^9 J. Twenty million tons of TNT gives 8×10^{16} Joules per H-bomb. Using (7) means that the power equivalent to 0.003 H-bombs/sec must be released from 11 light years away to detect this signal.