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DR. SETI'S STARSHIP

Searching For The Ultimate DX

Watching Terrestrial Television at Alpha Centauri

In our last column, we explored an attempt to beam the 2008 film *The Day the Earth Stood Still* to purported science-fiction fans at Alpha Centauri, our nearest stellar neighbor. We showed through link analysis that to watch the movie they would require an antenna on the order of 3200 km in diameter – roughly the size of a continent.

Although I refuse to rule out the possibility of advanced extraterrestrial beings engineering antennas (or arrays of antennas) of continental scale, there still remains the problem of pointing those immense antennas in our direction. Recall that the beamwidth of a parabolic antenna can be estimated from its diameter and operating wavelength. For the Centaurian antenna, that half-power beamwidth is on the order of:

$$\theta = \frac{\lambda}{D} = \frac{5.0 \times 10^{-2}\ \text{m}}{3.2 \times 10^{6}\ \text{m}} = 16\ \text{nRad}$$

which is on the order of a *millionth* of a degree. One shudders to think how any civilization, no matter how advanced, could aim a whole continent to that level of accuracy, much less track a moving target from a moving object for the length of a two-hour movie. However, more significantly, one must ask: Why bother?

One would think that by comparison to the Centaurians' challenge of aiming an antenna of continental size, our problem on Earth, pointing our tiny 5.5-meter uplink antenna, would be trivial. Not so, because although our antenna's half-power beamwidth is a respectable half a degree, we are dealing with an n-body Newtonian motion problem over interstellar distances.

Consider first that we are aiming our antenna from the surface of a planet that is both spinning on its axis and orbiting its star. That star is, in turn, revolving around the center of the Milky Way galaxy, as is the Alpha Centauri system. Our movie-going audience is ostensibly situated on the surface of a planet somewhere in that triple-star system. Unless it is tidally locked (not a happy circumstance for the emergence of life), that planet is doubtless rotating on its axis, and negotiating a complex orbital dance with respect to its *three* suns. Our own motion is known, or can at least be computed. Having not yet even detected our target planet, we can only guess as to its complex path over time.

"Over time" is our key here. Remember that when we look at Alpha Centauri in the southern sky, we are seeing not where it *is*, but rather where it *was* some $4^1/4$ years ago. Thus, when we transmit toward Alpha Centauri, our antenna must aim, and track, not where it *was* $4^1/4$ years ago, or even where it *is* today, but rather where it *will be* $4^1/4$ years hence.

True, our half-degree transmit beamwidth gives us some leeway. As our beam spreads out conically in interstellar space, there is a chance that we might get lucky and that part of our signal may end up intercepting its intended target. Then again, maybe not. It's not an easy matter for me, or the Deep Space Communications Network (DSCN), to calculate.

The foregoing calculations might well cast a pall over the whole SETI enterprise. How can we expect, one might wonder, to intercept incidental radiation from a distant civilization when our own broadcasts are most likely not detectable at even the nearest star, but for superhuman efforts and incredible antenna engineering?

The encouraging answer is that SETI science seeks not to watch movies (or, in fact, to demodulate intelligence of any kind) as much as to identify signals of clearly intelligent extraterrestrial origin, providing proof of existence of our cosmic companions. Let's think about how *The Day the Earth Stood Still* uplink might have provided proof of existence to our cosmic companions, over far greater distances than Alpha Centauri.

First, and most obviously, while demodulating viewable FM video requires a reputed positive signal-to-noise ratio on the order of 10 dB, we can detect the presence of an artificial signal at unity SNR, or even less. Thus, dispensing with that assumed 10-dB detector threshold allows us to decrease our receive antenna size by a factor of three, or alternatively, to increase our detection range for the originally computed antenna also by a factor of three. However, it gets even better.

Significant increases in detectability are achieved in SETI receivers by integrating a received signal over time. The longer the time averaging, the more a signal rises out of the noise. Of course, modulation (that is, information content) is lost in the process, but if we are seeking proof of existence rather than video entertainment, this is hardly a factor. In the present example, by integrating our received signal for a mere three seconds, we add an additional 40 dB to our SNR. This would allow us to increase distance by a factor of 100, or decrease receive antenna size by a factor of 100, or some combination of the two.

Finally, although a 40-MHz channel allocation (34-MHz receiver bandwidth) is typical for analog satellite TV, there are many modulation modes that concentrate considerable power into a far narrower bandwidth. Since narrowing receiver bandwidth improves SNR, we might expect to detect these narrower signals over far greater distances, or with significantly smaller antennas. A 500-watt carrier, for example, contained within a 10-Hz bandwidth could easily be detected over interstellar distances by an antenna such as Arecibo in Puerto Rico, Earth's largest radio telescope, given about 100 seconds of integration time.

Given the above, one wonders over what distance video programming from the DSCN can realistically be received given Earth-level technology. It turns out that an Arecibo could recover clear video

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from this uplink out to a range of about 3-billion km. This figure represents the approximate distance between the Sun and Uranus at aphelion. Thus, an Arecibo Observatory on Uranus could, if properly aimed, be used to monitor Earth's satellite TV uplinks.

Bear in mind that the uplink facility used at DSCN initially was intended to relay FM video via a communications satellite parked in the Clarke orbital belt, a mere 38,000 km from Earth. This is a facility designed for relatively local communications. That it appears capable of interplanetary video relay is encouraging. It should not disappoint that its utility over interstellar distances seems suspect.

"Give me a lever long enough," wrote Archimedes more than two millennia ago, "and a fulcrum on which to place it, and I shall move the world."

"Give me an antenna large enough," wrote the Alpha Centaurians, "and a target at which to aim it, and I shall watch your world."

Their task in viewing *The Day the Earth Stood Still,* though not inconsistent with the laws of physics, is nonetheless daunting beyond belief.

73, Paul, N6TX

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