Mind Where You Are Leaking

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Introduction

In the 1997 film of Carl Sagan's novel, Contact, first contact is made with an alien civilisation. The signal received from space at a Search for Extraterrestrial Intelligence (SETI) receiving site contained a repeated portion of a 1939 television broadcast of Adolf Hitler. While Contact is fiction, the possibility that signals originating on Earth could be received by alien intelligences is real. This essay addresses the issue of signal leakage from our planet, whether it's a problem, and how we can use such leakage to our advantage.

Leakage

In 1901, Guglielmo Marconi made what was arguably the world's first long-distance radio communication: from Cornwall to Newfoundland. In 1921 voice transmissions began, followed by the first crude public television broadcasts in 1928. These early transmissions were weak but they effectively mark the start of a continuous stream of artificial signals leaving Earth for deep space.

Any radio signal made on Earth has the possibility of leaving the Earth. While the transmissions are intended for earth-bound receivers, transmissions are often omnidirectional. Even directed transmissions, such as those from microwave dishes aimed horizontally, eventually head skyward as the Earth curves away from beneath the main signal beam. Once a signal is travelling skyward, only the atmosphere exists to block their departure. The atmosphere is, however, only transparent to a range of frequencies: approximately 30 megahertz to 30 gigahertz.

The range of transparency to radio emissions is called the atmosphere's radio window. The lower limit on the window is imposed by a thin layer of charged particles in the upper atmosphere, called the ionosphere. Reflections off the ionosphere are largely responsible for our ability to receive, in Australia, timing radio signals from the US-based NIST WWV transmitter. The behaviour of the ionosphere is variable with the diurnal cycle and the level of solar activity, so signals may be blocked more or less effectively at varying times. The upper limit on the radio window is largely imposed by the interaction of radio signals with water, ozone, and oxygen in the atmosphere. In the range of the atmospheric radio window are frequency allocations for commercial radio and television broadcasts, land and sea-based mobile communication, radio-navigation aids, and many other uses.

A Problem?

Given that we are leaking all sorts of transmissions and information there is the possibility that an alien intelligence could intercept the information and use it in ways we'd rather not have it used. There are several factors involved in this possibility considered in the following paragraphs.

The first television transmissions left Earth around 1930, so the wave fronts are approximately 70 light-years from Earth. The NStars Project [1], which aims to catalogue stars within 25 parsecs (81 light-years) of the Sun, currently lists 1936 objects within the 70 Ly radius. This catalogue is, however, not complete with current expectation of about 7500 stars inside 25 parsecs. Of the 102 known extra-solar planetary systems [2] approximately 20 are within 70 light-years, and only a handful of planets fall inside what we'd call the habitable zone. Therefore, the number of possible intelligent lifeforms is expected to be low, making the likelihood of stray signal interception similarly low.

However, the presence of signals is only part of the picture. To eavesdrop on our leaked transmissions, an alien intelligence must actually be listening. Any alien eavesdropper would clearly need to either make an educated guess at likely frequencies, as we have with the SETI@Home project and 1420 megahertz, or scan the entire radio range. As the leakage range is dictated by Earth's atmosphere, something unknown to the receiver, the listener may look at ranges suitable for their atmosphere and detection will only be possible in the overlap. Further, since no single antenna is optimal for scanning the entire leakage range a collection of listening systems would be required for any whole range search: just as a range of antennas is required for radio, television, and satellite reception on Earth.

Detection must occur before useful contact could be made. Assuming the leaked signal was a 10000 watt omnidirectional television transmission then, at the distance of the nearest star, Proxima Centauri at 1.295 parsecs, the detectable signal is only about $5 \times 10^{-31}\mathrm{Wm}^{-2}$. For comparison, signals from the Pioneer 10 spacecraft 30 years after launch were received using DSS 63, a 70 metre radio telescope near Madrid. The signal amounted to $1.4 \times 10^{-18}\mathrm{W}$ (-178.5 dBm) [3], or $3.7 \times 10^{-22}\mathrm{Wm}^{-2}$ over the $3850\mathrm{m}^{-2}$ area of the dish. The signal was only barely detectable among the background and receiver noise. The same antenna trying to receive the leaked transmission at Proxima Centauri would have only $2 \times 10^{-27}\mathrm{W}$ to work with, and exponentially less at greater distance. Consequently an alien intelligence would need an exceptionally large antenna just to detect our leaked signal and would still have to extract it from the noise.

Having detected a signal the task of extracting any information from it can begin. There are a multitude of ways to encode information onto a carrier signal and none of these is an "obvious" choice. For example, modern analogue television signals are a compound of frequency modulated audio and amplitude modulated vision signals [4], and the vision signal is itself a compound of brightness, colour, and timing signals. While repetitive patterns could help to unravel the signal the task seems a very complex one if no prior knowledge is assumed. Modern digital television broadcasts, which use spread spectrum, digitally compressed signals would most likely remain indecipherable to analysts.

Of course, a far more technologically advanced civilisation may be able to overcome some of the problems but some, like the collecting area needed, could not be avoided. Further, anybody willing to build such a galactic eavesdropping system seems more likely to be curious than belligerent. The combination of detection, analysis, and interpretation problems, coupled with a low probability of intelligent life in the 70 light-years around Earth make the likelihood of leakage signals being problematic vanishingly small.

To avoid detection humankind probably has little to do. If frequencies within the atmospheric windows are used then leakage will occur. However, provided radiated power is kept to a minimum the likelihood of detection, even at the nearest star, is quite low. Using spread spectrum transmission systems will reduce the chance of detection and information extraction. Conversely, to increase our chances of detection we need to start transmitting substantial power on frequencies likely to be listened to, such as those signals projects like SETI@Home are expecting to detect.

Useful Leakage

If we are leaking artificial signals into space then it is reasonable to assume that any similar civilisation in another solar system (or our own) will be doing likewise. However, for the same reason that an alien intelligence is very unlikely to intercept our leakage, we a similarly unlikely to intercept theirs. If we did intercept a signal through some serendipitous event we'd most likely gain no useful information from it other than its value as an indicator of intelligent origin.

The SETI searches to date have concentrated on a few, very narrow bands about specific frequencies. None of these searches has been aimed at detection of accidental emissions but rather look for deliberate beacon signals. The search frequencies, particularly the 1420 megahertz neutral hydrogen emission frequency, have been chosen because there are natural phenomena that may prompt the use of that frequency for a beacon. The beacon signals would need to be very strong and deliberate in order for us to detect them over the immense distances involved.

Conclusion

Since the early days of radio and television we have been leaking artificial transmissions into deep space. Only those transmissions that fall within the range of our atmosphere's radio window will have escaped. At the distance of the nearest star a typical television transmission would be about 9 orders of magnitude fainter than signals from Pioneer 10 that were barely discernible on Earth. A massive collecting area would be required to gain enough signal to process, and then the problem of extracting and interpreting information could begin. The same problems apply to any attempt by mankind to detect alien leakage signals. Any civilisation undertaking a wholesale search for leakage signals must be very curious, as we are, so it seems unlikely that such a civilisation would use information gleaned in a wholly negative way. In any case, the likelihood of detection of current leakage signals is very small indeed.

References

[1] Nstars database. NASA. Internet `http://nstars.arc.nasa.gov/index.cfm`.

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[3] Lawrence Lasher. NASA. Internet `http://spaceprojects.arc.nasa.gov/Space_Projects/pioneer/PNStat.html`, Sep 2003.

[4] Australian Broadcasting Authority, Canberra, Australia. *Radio and Television Broadcasting Stations*, July 2003.