By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

Beckoning Beacons

How do you know if your rig is working? "Easy," you say. "Just call CQ and see who answers." True, but if the nearest DX is light years away, you can grow old, cold, and lonely awaiting that "QRZ" from Beyond. Such is the dilemma facing those radio amateurs pursuing interstellar DX, a practice otherwise known as SETI.

Maybe you're not trying to work DX at all, but are just an SWL. This, in truth, is more the case for the hundreds of amateur observers in the grass-roots, nonprofit SETI League who build sensitive microwave receiving stations, seeking radio evidence of technological civilizations out there among the stars. A receiving station is less costly than one that also transmits, for two reasons. The obvious reason is that a shortwave listener need not invest in a transmitter. However, beyond that truism, on a galactic scale (where transmitters need to radiate power levels that boggle the imagination), being a passive listener puts the burden of generating gigawatts right where it belongs—squarely on the shoulders of our (presumably older, wiser, and wealthier) cosmic companions. Earth is, after all, a young planet orbiting a young star. Other species, if they exist, are likely to be more ancient. If their planet has an expanding economy (a principle terrestrial economists call "inflation"), then they can afford better than we to radiate incredibly strong beacons, which just might reach our modest receivers as incredibly weak noise.

Now, receiving those feeble signals on Earth is no easy task. It requires searching through the quietest part of the spectrum, with the highest gain antennas, the most efficient feeds, the lowest noise receivers, and the cleverest digital signal processors we can muster. Thus, radio astronomers (whether professional or amateur) and those engaged in the scientific Search for Extra-Terrestrial Intelligence go to great pains for that extra tenth of a dB of sensitivity, as do weak-signal microwave DXers and moonbouncers. In fact, the SETI and EME communities have such a commonality of purpose that it makes good sense for them to share their technology, which is where our story begins.

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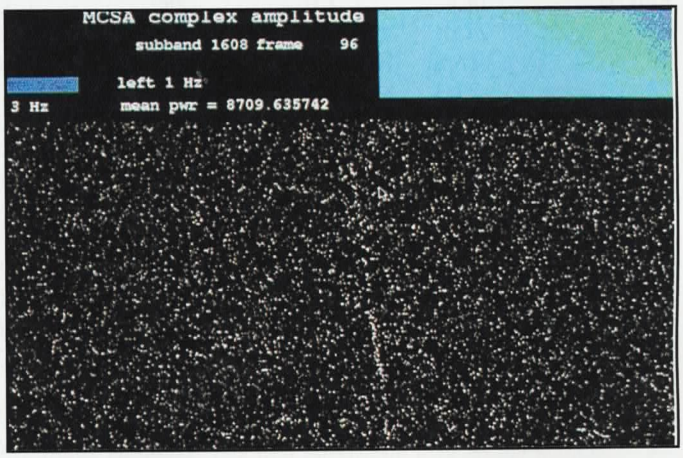

Figure 1. Drift-scan sweep of Quasar 3C273, about 3 dB out of the noise.

Natural Calibration Beacons

"You can't work 'em if you can't hear 'em," the saying goes. But how do you know if you can hear 'em, considering you don't even know for sure that they exist?

Forget ET for just a moment, and consider that the universe

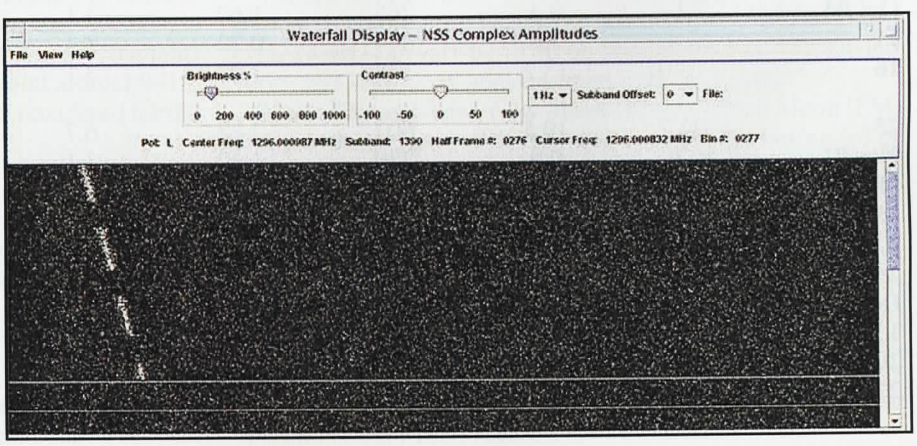

Figure 2. Mars Reconnaissance Orbiter beacon received by F5PL from Martian orbit.

is full of natural radio emissions. Stars, planets, moons, pulsars, quasars, supernova remnants, and even the chemicals that populate the black void between the stars all emit microwave radiation. Since its earliest days, radio astronomy has sought to study these emissions. Some are of known power, so you can calibrate your receiver's sensitivity on them. My favorite quasar, for example, 3C273, is known to emit +46 Janskys (a linear measure of flux density) on Earth at a frequency of 1420 MHz. Therefore, when I receive it 3 dB out of the background noise (see figure 1), I know the sensitivity of my receive station is half that level, or +23 Janskys. (This is, incidentally, a level of sensitivity typical of amateur radio telescopes and 23-cm moonbounce stations.) If I monitor 3C273 after tweaking my station and the received signal strength increases, I know my receiver is working better. If signal strength goes down, I know I should have left well enough alone.

Artificial Calibration Beacons

Since the beginning of the space age a half century ago, humans have been lobbing debris into space. Most of our space probes carry radio transmitters to send scientific (or perhaps less noble) data back to Earth. Might the signals emanating from our own spacecraft serve as calibration signals for terrestrial radio telescopes?

Indeed, they might, do, and have. Figure 2 shows a popular beacon signal from the Mars Reconnaissance Orbiter received in France (which, last time I checked, was on planet Earth) by amateur radio astronomer Bertrand Pinel, F5PL, as the spacecraft entered orbit around the Red Planet in March 2006. Since we know the beacon's power, we can use this signal to verify and quantify our station's performance. (Of course, the distance between Earth and Mars is always changing, so we need to do a little math to calculate the effects of varying path length and corresponding variations in isotropic free-space path loss.) Since we now have spacecraft orbiting or landing on many of our neighboring planets, as well as in orbit around the Sun, and orbiting the semi-stable Lagrangian points of the Earth-Sun and Earth-Moon two-body systems, we can enjoy calibration signals from a plethora of sources in space, all of Earthly origin.

SETI Calibration Considerations

Given the wealth of available natural and artificial calibration sources in space, which would prove most useful for the SETI enterprise? Consider that one challenge facing SETIzens is distinguishing between natural and artificial radio emissions. The latter tend to be extremely broad in spectrum, typically spanning MHz to GHz. Signals of technological origin tend to concentrate their energy in discrete carriers and sidebands. Thus, even in the case of purportedly wideband artificial emissions such as spread spectrum, detection against a backdrop of broadband natural radiation is facilitated by their narrowband spectral components. It follows that while wideband astrophysical sources serve us well as calibrators for continuum radio telescopes, those instruments optimized for SETI detection should be tested against artificial signals that closely replicate the narrow-band intelligent emissions that they seek.

For about three decades a popular SETI calibration source was the 20-watt S-band beacon aboard the Pioneer 10 space probe, the first human artifact to travel beyond the edge of our solar system. By the beginning of the 21st century, this robust calibrator had traveled beyond the range of even our most sensitive radio telescopes, forcing the SETI community to seek a calibration alternative.

In the next column, we will reveal how radio amateurs rallied to fill the gap.

73, Paul, N6TX