Progress in the Search for Ultra-Narrow Band Extraterrestrial Artificial Signals from Argentina

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Abstract. Project META (Megachannel Extra-Terrestrial Assay), a full-sky survey for artificial ultra-narrow-band signals, has been conducted in Argentina, since October 1990, from one of the two 30-m radio telescopes of the Instituto Argentino de Radioastronomía (IAR). The search was performed near the 1.4 GHz line of neutral hydrogen, using an 8.4×10^6 channel Fourier spectrometer of 0.05 Hz spectral resolution and 400 kHz of instantaneous bandwidth. The observing frequency was corrected both for motions with respect to three astronomical inertial frames, and for the effect of Earth's rotation, which provides a characteristic changing signature for narrow-band signals of extraterrestrial origin.

In 1996, with the economical sponsorship of *The Planetary Society*, an upgrade of the original META data acquisition system was made. New hardware was installed and new software was developed allowing a more comprehensive data analysis of the detected signals. The search was expanded to the 1.667 and 3.3 GHz observing frequencies. A description of the new system's characteristics as well as the results of the first observations will be presented.

1. Introduction

Almost forty years of SETI studies have repeatedly indicated that searching in the microwave spectral range is a very promising approach. Existing terrestrial radio-astronomical technology is sufficiently sensitive to detect extraterrestrial artificial signals, no much stronger than some leaving Earth (Lemarchand 1998a). Although it is perhaps natural and seems reasonable to many to assume that planetary systems and life are typical, we realize that there may be enough variety in the Milky Way and enough cosmic time to lead the evolution of beings, civilizations and technological levels far different from us. It could be technically possible that a few of those hypothetical civilizations are transmitting beacons many orders of magnitude stronger than the rest of the existing galactic civilizations. The rationality of making full-sky surveys for ultra-narrow-band artificial signals, compared with the target-search strategies (e.g., Project Phoenix) is based in the fact that it is much easier to detect those beacons that are intrinsically strong, but remote, than those that are nearer but weaker. Drake (1973) showed that this is true even when for every 300 civilizations transmitting at certain radio power, there is but one civilization, which transmits signals ten times more powerful. Under these assumptions, it makes sense to perform a complementary strategy for the target search. A full-sky survey takes the advantage of scanning in all sky directions trying to get the strongest signals at the so-called "magic frequencies" (frequencies that have some universal physical characteristics that are more advantageous than others in the cosmic dial).

However, recent full-sky surveys made from Harvard, Arecibo, Ohio (all in the USA), Buenos Aires (Argentina), Parkes (Australia) and Medicina (Italy) were unable to find any conclusive evidence of omnidirectional supercivilization transmissions at a distance of 22 Mpc (7×10^7 light years). Using Kardashev's classification of the energy outputs supercivilizations, these conclusions assume that these hypothetical signals would have a radiated power equivalent to the entire energy output of a solar type star, or about 10^{26} watts. We can conclude that there are no such civilizations in the Milky Way in M31 (the nearest galaxy like our own) in M33, M81, the Whirlpool Nebula, Centaurus A, nor the Virgo Cluster of galaxies.

2. The META II System Upgrade

The META II system, an 8.4 million channel spectrometer to perform a full sky survey for artificial narrow band signals, has been used from one of the two 30-meter radio-telescopes of the Instituto Argentino de Radioastronomía (IAR) for almost 10 years. The IAR has two 30-meter parabolic antennas with an equatorial mount. One of the radio telescopes can be used 12 hours a day to perform a SETI sky survey in southern declinations between $-90 \leq \delta \leq -10$ degrees. After more than 20,000 hours of observations and 3×10^{13} spectral channels already analyzed, we obtained some 40 extra-statistical events or "alerts". Unfortunately, the software and hardware available with the original system did not allow us to determine the real origin of these "alerts" (Lemarchand *et al.* 1997). Cordes *et al.* (1997) showed that the original META re-observations (following the source for periods of one hour) were incapable of ruling out the case where a real ETI source with a constant, intrinsic signal strength underlies the measured candidate signal. This conclusion holds even for the case where the interstellar scintillations remain correlated between the time of an initial detection and prompt re-observation. This was, due to the impossibility – with the original META system – of integration within the same frequency window (with 0.05 Hz spectral resolution) for periods of hours to avoid these interstellar scintillation effects (Lemarchand 1998b).

With the sponsorship of *The Planetary Society* a new data acquisition system for the META II spectrometer was developed by the IAR engineers. The main advantages of the new system are the following: the possibility of integration times from fraction of seconds to hours in a specific high resolution frequency domain window, the possibility to use it as a high resolution astronomical analyzer (e.g., for the study of high resolution OH masers profiles), the use of lower thresholds with the correlation analysis of the interesting candidate signals found in previous observations and the expansion of the instantaneous bandwidth. The new system is also able to control the antenna movements, local oscillators, frequencies, frames, polarizations, Intermediate Frequencies (IFs), post-detection

Figure 1. One of the two 30-meter radio telescopes of the Instituto Argentino de Radioastronomía, 45 km south from Buenos Aires, Argentina.

data analysis, etc. Now, it is possible to switch between any of the two 30-meter radio telescopes and to expand our search to other observing frequencies (1.4; 1.67; 3.3 GHz). The new system has been in operation successfully since mid 1999.

3. OH Masers as Amplifiers of ETI Signals

Gold (1976), Lemarchand (1992) and Cordes (1993) pointed out the possible use of astronomical masers for interstellar communication. Interstellar and circumstellar masers are natural amplifiers of high gain, so long as they are not saturated. Cordes (1993) showed that weak ETI sources, otherwise detectable at only parsec distances, might be rendered detectable across the galaxy if viewed through a cosmic maser.

Unsaturated masers have level populations unaffected by radiation at maser frequency, thereby allowing the intensity to increase exponentially with maser length (Elitzur 1992) as $\mathrm{I} = \mathrm{I_B} e^{\tau} + \mathrm{IME}$. Here τ is the optical depth (absolute value), IME is the internal maser emission and $\mathrm{I_B}$ is the background intensity, with contributions from both the 2.7 K cosmic background radiation and eventual ETI signals. Internal maser emission shows line widths narrower than those expected from Doppler broadening by factors of 4 to 5. Unsaturated masers yield

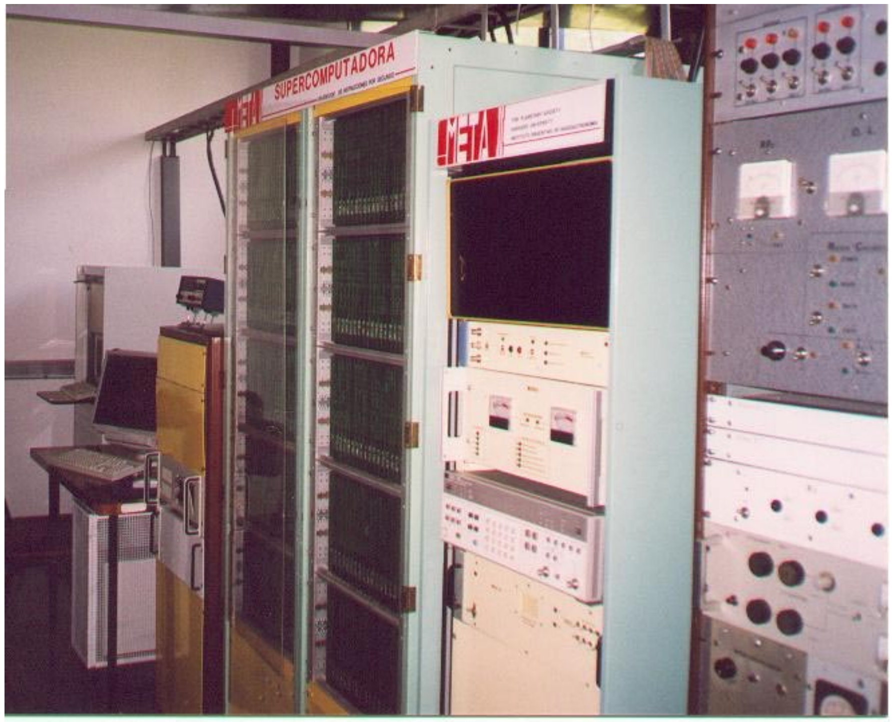

Figure 2. A view of the META II 8.4 million channels analyzer with the new data acquisition system at the IAR's Observing Room.

line widths $\simeq \sqrt{\tau}$ suggesting maser gains $\simeq e^{\tau} \approx 10^7$ to 10^{11}. Such masers can amplify by large factors any fastly varying (encoded) extraterrestrial artificial signal.

Transmitting civilizations may choose appropriate directions in which to transmit on the basis of surveys of natural emission, including those where maser clouds and filaments are already identified. For example, the OH galactic plane survey, made by Turner (1979), detected OH emission in 75 % of the directions searched in the region $337 \leq l \leq 35$ degrees, 51 % in the region $35 \leq l \leq 85$ degrees, and 19 % in the region $85 \leq l \leq 270$ degrees. The biggest payoff probably involves compromises between the estimated gains from specific maser clouds, the sizes of the clouds, proximity to the transmitter and the number of stars to be found downstream of the maser cloud (Cordes 1993).

Cohen *et al.* (1987) have completed a series of OH/IR stars using a prototype of the original NASA SETI Spectrometer with a 300 Hz spectral resolution and found that the natural cosmic maser features have a line widths over $\approx$ 500 Hz. Artificial signals can be much narrower ($\approx$ 1 Hz), this implies that they would be decreased by a factor of 500 or more in most studies of OH masers and by even larger factors at higher frequencies.

Using the advantage of the META System ultra high resolution ($\approx$ 0.05 Hz) for the four microwave OH lines (1.612, 1.665, 1.667 and 1.72 GHz) in the direction of the southern hemisphere OH masers, we will be able to combine a "magic direction" in the sky (cosmic masers), with "magic frequencies" (OH lines) and the advantage of the higher gains due to the natural maser amplification effect. This is an interesting optimization of the use of natural physical laws to improve the odds of detection of extraterrestrial intelligent transmissions towards the direction of our solar system.

The OH survey from the IAR will be initiated by the end of year 2000, using a high gain feed with a 35 K system temperature. We hope that this survey will be also able to reveal broad, natural lines covering many frequency channels while hypothetical ETI signals would cover only some tenth bins. We will try to follow the suggestions of Cordes *et al.* (1997) to repeat observations of each sky position at intervals longer than the characteristic interstellar scintillation time, of order hours at these frequencies. At least 4 to 6 repeated scans would help counteract the deleterious effects of scintillations.

4. Observations

The observations with the newly upgraded system started during mid 1999. During this time, we performed several observations, both at target and survey modes and at several frequencies (1.4; 1.667 and 3.3 GHz) using each of IAR's two radio telescopes. During the last year, several new software and processing tools were developed to improve the quality and performance of the data acquisition and post processing systems. We have already finished a series of 2 hour-long observations, at each of the mentioned frequencies, around all the recently discovered extrasolar southern hemisphere planetary systems that are between declinations of $-90 \leq \delta \leq -10$ degrees. The list of extrasolar planetary systems stars includes GJ3021; HR810; Gliese 86; HD75289, HD82943; HD83443; HD52265; HD108147; HD134987; HD168746; Gliese 876 and HD169830. No ultra narrow band signals were observed during these runs. By the end of 2000, a galactic plane high-resolution sky survey will be initiated in order to test the hypothesis described in the previous section.

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