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SETI@Arecibo

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SETI as a Commensal Activity for the Arecibo Observatory

Introduction: Contact with an extraterrestrial civilization will be the greatest human discovery ever made. The empirical evidence that rational complexities exist across the universe will surely change our human prospects for the future.

In the last century humanity has developed the technical ability to search for extraterrestrials, particularly if they are also attempting to search for others and are transmitting signals. In this regard Frank Drake's Ozma Project carved a path to search for 'intelligent' radio signals with sensitive radio telescopes. Several search programs have taken place, using radio telescopes, in the last few decades with no detection of any credible extraterrestrial signals (SETI signals). However, the number of intelligent technological civilizations in our galaxy may not be very large and very extensive searches may be needed to make a detection.

To maximize our chances for detecting radio signals from intelligent technological extraterrestrials we must use telescopes to search for a wide variety of possible signal types. Key aspects of the search space for ETI signals include wide field of view, diversity in the frequency-time plane, and sensitivity. SETI is part of the long term plan for the Square Kilometer Array and for pathfinder telescopes for the SKA, including the Allen Telescope Array. SKA pathfinders will reach a 10% sensitivity level (of the full SKA) no earlier than the middle of the next decade. Since Arecibo is already a 10% SKA in terms of sensitivity, it is clear that SETI can and should be done with the most sensitive radio telescope available to us *now*. The telescope should be used to search for SETI signals on a continuous basis, used simultaneously with other scheduled experiments. Data should be archived and analyzed with automated systems that alert researchers for any potential signals.

If we do not search our chances of finding SETI signals are zero; if we search we may make contact. This search is worth a "ton of gold" and can be activated with modest investment. Nondetection of SETI signals, after a very long search, will also teach us how rare we are, and this will also affect our human behavior.

The Arecibo radio telescope is a diverse multipurpose telescope and can easily accommodate a permanent SETI experiment. This should be one of its missions. SETI@Arecibo will have a broad impact, both during the "hunt," in which the public can participate, and certainly if there is a detection.

A Ten Year Program for SETI at Arecibo: The Arecibo L-band Feed Array (ALFA) is currently being used for surveys of the Milky Way to find pulsars, to study Galactic hydrogen and magnetic fields, and to study ionized gas in recombination-line surveys. ALFA is also being used for all-Arecibo-sky extragalactic hydrogen surveys. The current plan is to develop wide-band SETI spectrometers for each of the seven ALFA feeds and do SETI surveys commensally with most of the ALFA surveys. These surveys will extend for at least another five years, with ten years more likely using new instrumentation that extends the frequency range.

SETI with Arecibo can include the following elements:

1. **Commensal ALFA SETI:** A seven-beam SETI program can proceed continuously once appropriate spectrometers have been constructed and deployed. These would comprise dual-polarization, >billion channel polyphase filter banks with an automated analysis and also a SETI@Home style public component.
2. **Commensal low-frequency SETI:** Development and use of multiple pixel feed arrays at frequencies lower than ALFA, e.g. 0.9 to 1.2 GHz, to extend extragalactic surveys in redshift will provide additional opportunities for SETI in this band.
3. **Commensal high-frequency SETI:** Molecular studies suggest the development of a multiple pixel feed array (or arrays) in the 3 to 6 GHz band, of equal interest for commensal SETI. These systems may make use of phased arrays if technology development now being done in Australia and Canada for SKA pathfinders is successful. If not, conventional feed clusters (the ALFA approach) can be used.
4. **Data Mining Technique Development:** SETI is closely related to detection of transient celestial signals and RFI. Techniques for transient detection necessarily confront contamination and discrimination from RFI. The same is true for SETI. Envisioned ETI signals are essentially a subset of all the signals that appear or might appear in the frequency-time plane. A long term program for Arecibo should therefore confront the data acquisition and processing of wideband dynamic spectra that detects and classifies signals, be they of terrestrial or celestial origin.

5. **Data Management:** Data sets suitable for SETI detection are valuable legacies. Surveys and data archival should be designed so that data and processing data products can be saved for the indefinite future and that tools for mining the archived data be made available.
6. **Multiple site SETI:** Data acquisition at multiple sites provides a powerful discriminator for interference and potential SETI signals. Over the course of the next decade, SKA pathfinders, including the Allen Telescope Array, and perhaps the GBT, can be used along with Arecibo for this purpose. Additionally, Arecibo candidate detections can be used to trigger observations with other instruments, as was done for Project Phoenix.
7. **Public Participation:** The enormous success of SETI@Home should be built upon in future Arecibo SETI and it should be made manifestly clear that Arecibo is the source of the data. Arecibo should become a trademark, in effect. Contributions to Arecibo should be encouraged and mechanisms for making them enabled.

Summary:

1. **Science:** Searching for signals from other civilizations
2. **Surveys and followup:** SETI surveys should be all the sky all the time, when practical. As much of the available frequency band should be covered through synergistic use of feeds and receivers as they are developed for astrophysical purposes. Followup protocols using Arecibo alone and in conjunction with other telecopes need to be worked out.
3. **Technology:** Multiple pixel systems with accompanying SETI backends are needed. These will trend toward GHz bandwidth systems (or more) with 1 Hz (or less) channel bandwidths. Data should allow exploration of the time-frequency plane with as wide a range of resolutions as is practical. Data management should strive to save as much data as is affordable to allow data mining with algorithms of the future as well as the present. Careful thought to storage and retrieval is needed.
4. **Broader impact, including outreach:** SETI has broad impact even without detection. SETI@Arecibo should build upon the great success of SETI@Home in engaging worldwide users in the search. A hierarchy of processing capabilities with different levels of software complexity and hardware requirement should be considered to stimulate and accomodate a range of involvement with SETI. A detection, of course, would have unprecedented impact.