Search for Artificial Signals from Nearby Stars Using the Berkeley SERENDIP III Data Set

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Abstract. We searched the SERENDIP III positional database for observations of especially interesting nearby late type stars that were encountered by chance in our all-sky survey. We examined the radio emission from these locations for possible indications of an artificial signal. We found no signals that were not consistent with random noise.

1. Introduction

The first radio searches for extraterrestrial intelligence used dedicated telescope time to search for emission from nearby stars, although the Berkeley SERENDIP project (Search for Extraterrestrial Radio Emissions from Nearby Developed Intelligent Populations) began an all-sky survey over twenty years ago (Bowyer, et al, 1983). The Ohio State program (Dixon, 1985) was another early all-sky survey effort.

Current radio searches are divided between all-sky surveys as carried out by the Harvard group (Leigh & Horowitz, 1997), Argentina (Lemarchand, et al, 1997), Berkeley (Bowyer, et al, 1997), Australia (Stootman, et al, this volume), and targeted searches of nearby stars as is carried out by the SETI Institute (Tarter, 1997).

The SERENDIP III program carried out a four year all-sky search using the world's largest radio telescope at Arecibo. In this search we covered 93% of the observable sky at least once, and 44% of the sky five times or more, with a sensitivity of $\sim 3 \times 10^{-25} W m^{-2}$. Information was obtained from over 10^{14} independent data points.

Although the SERENDIP III search was an all-sky survey, we note that in carrying out this survey nearby stars inevitably fall within the beam pattern of the telescope. As part of the analysis of the SERENDIP III data set, we have investigated the data from those regions of the sky coincident with nearby stars. Although our integration times are relatively short as compared with the SETI Institute targeted search, our sensitivity is still substantial because of the large collecting area of the Arecibo Telescope and the outstanding receivers that are available for use with this instrument. Given the large range of parameter space in which an extraterrestrial signal might be transmitted, we believed that it was worthwhile to search this data set for potential artificial signals.

2. Observations

The SERENDIP III data were obtained with the National Astronomy Ionosphere Center's radio observatory in Arecibo, Puerto Rico with a 430 MHz receiver. Data from this receiver were fed to the SERENDIP III four million channel spectrum analyzer. This analyzer had a 1.7 second integration period and a 0.6 Hz frequency resolution (2.5 MHz instantaneous band coverage). In order to cover the receiver's entire 12 MHz intermediate frequency signal, the SERENDIP III instrumentation mixed the IF with a signal generated by a local oscillator. By stepping the local oscillator signal SERENDIP III processed the entire IF in 2.4 MHz steps taking about 8.5 seconds to complete a single IF sweep. The SERENDIP III hardware is described in detail by Werthimer, et al (1997).

SERENDIP III's 0.6 Hz frequency bin size is wide enough to encompass Doppler frequency drifts caused by the Earth's motions plus reasonable accelerations of the transmitter's reference frame. The signals obtained are analyzed by an extensive software system (Cobb, et al, 1997). This system first identifies and rejects most human interference which could mimic, in part, an expected ETI signal. After rejection of these spurious signals the data is subjected to a number of signal detection algorithms, which are designed to identify signals of special interest.

We obtained the Marcy and Butler list of stars being studied by these workers (Marcy, private communication) with the rationale that they had taken special care to identify good candidates for planetary systems. We also obtained the Center for Astrophysics list of G-dwarf stars within (roughly) 100pc of the Sun as listed on their web site (http://cfa-www.harvard.edu/~latham/planets) with the rationale that these were also good candidates. We identified those stars in these lists visible with the Arecibo telescope (i.e. stars between -2° and $+38^\circ$).

We checked the Marcy and Butler list against the Hipparcos catalog and eliminated those stars without Hipparcos determined distances since we wanted accurate source luminosities. We then searched the SERENDIP III positional data set and identified those stars that fell within the halfpower beamwidth of the Arecibo antenna. The resultant Marcy and Butler list included 237 candidates of which 224 were observed by SERENDIP III at least once, and 194 were observed multiple times. In Figure 1 we show the percentage of this sample observed as a function of number of times observed.

The median distance of this sample is 22pc, corresponding to an upper limit transmitted (isotropic) signal power of 1.7×10^{12} watts. We note that the sensitivity limits are uncertain to a factor of 2 because we used the average sensitivity of the antenna rather than the sensitivity at the exact position of the star within the beam.

In the case of the CFA G-dwarf sample, 516 stars are observable with the Arecibo telescope. Of these, 494 had been observed at least once, and 439 had been observed multiple times. In Figure 2 we show the percentage of this sample as a function of the number of times observed. We checked the distances of these stars with the latest Hipparcos distances. The median distance of this sample is 45pc, corresponding to an upper limit transmitted power of 7.2×10^{12} watts.

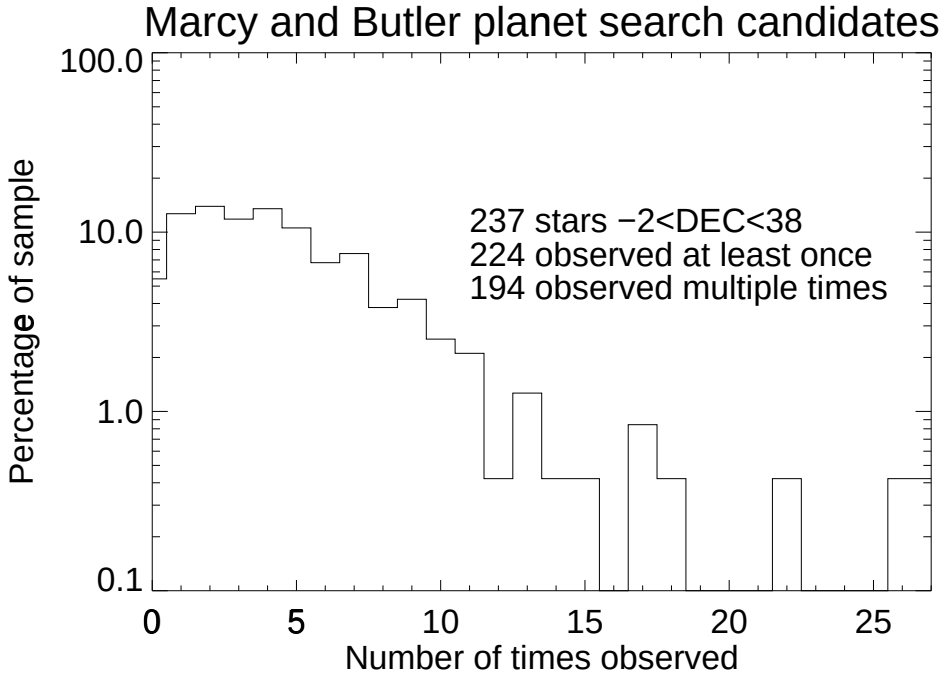

Figure 1. A histogram of the number of times each star in the Marcy and Butler derived sample was observed by Serendip III.

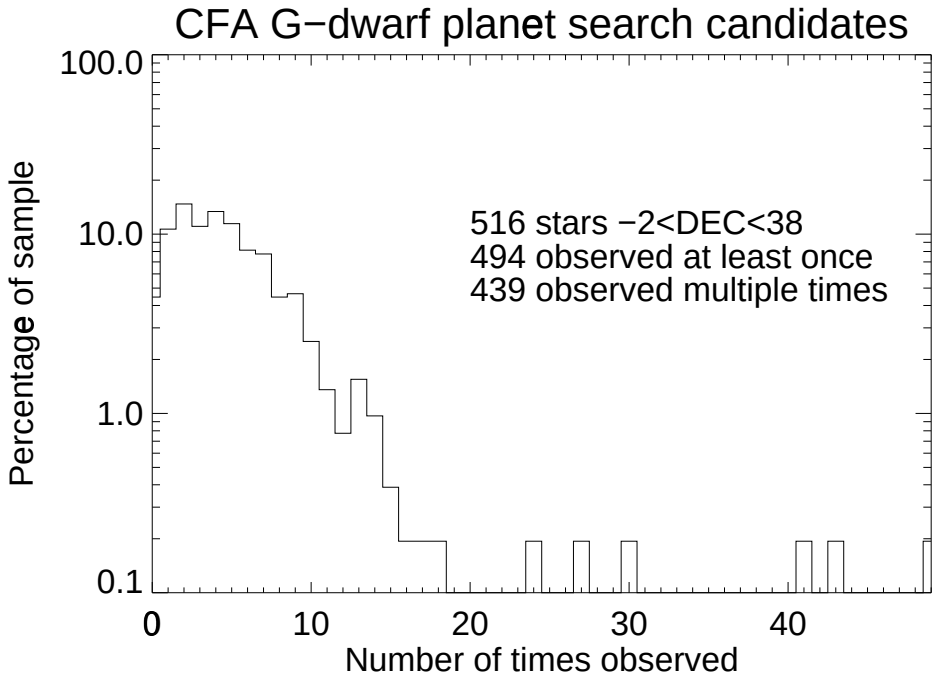

Figure 2. A histogram of the number of times each star in the CFA G-dwarf derived sample was observed by Serendip III.

3. Results

No excess power was detected in the radio emission at the locations of any of these target stars, beyond that expected from statistics. We will provide individual upper limits to the emitted flux from these stars in a forthcoming publication.

4. Acknowledgements

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