BREAKTHROUGH LISTEN

Searching for Signatures of Technology

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Overview

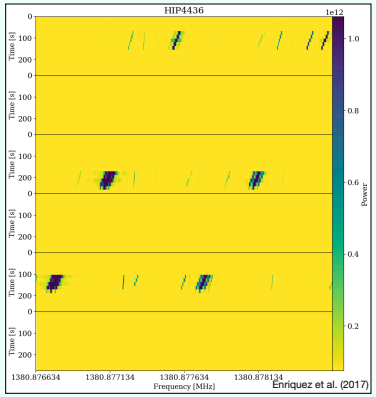
Breakthrough Listen (BL) is the most comprehensive search for signs of extraterrestrial technology ever undertaken. Using some of the most powerful telescopes in the world, combined with an unprecedented capability to record, archive and analyze the incoming data, Breakthrough Listen is humanity's best hope of detecting evidence for technological civilizations beyond the Earth. BL his currently observing a focused target list consisting ~1700 nearby stars and ~150 nearby galaxies. Our observing strategy is expressly designed to to allow us to to effectively work through the mountains of radio frequency interference (RFI) that inhibit the identification of candidate signals.

Observatories

BL Partners with The Green Bank Observatory in West Virginia to use the Green Bank Telescope, The University of California's Lick Observatory on Mt. Hamilton to use the Automated Planet Finder (APF), and the Australian National Telescope Facility in Australia to employ the icon ic Parkes Telescope. The 100m GBT has some of the most sensitive single pixel radio receivers in the world, capable of detecting the Voyager I spacecraft, and its 10 watt transmitter at a distance of 140 AU away from the Earth. The APF is capable of detecting diffraction limited lasers, in the optical regime from transmitters of order a megawatt for nearby stars. The Parkes telescope, with its multi-beam receiver will perform a survey of the Galactic Plane, with unparalleled sensitivity.

Search Results

In the first analysis of BL data, including 30 minute cycles of observations of 692 targets from our stellar sample, we find that none of the observed systems host high-duty-cycle radio transmitters emitting between 1.1 to 1.9 GHz with an EIRP of 10^{13} watts, a luminosity readily achievable by our own civilization. This comprehensive search over hundreds of stars represents only a small piece of the ever growing data set being compiled by Breakthrough Listen.



Enriquez et al. (2017)

Above, five minute on/off observations show signals in the 'on' observations, which are absent in the 'off' observations, indicating the signals are isolated on the sky and not from radio frequency interference on the ground. These signals are likely satellites in Earth's orbit, passing through the beam or emanating from terrestrial transmitters with pathological duty cycles.

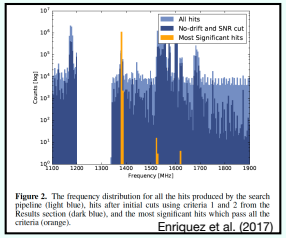
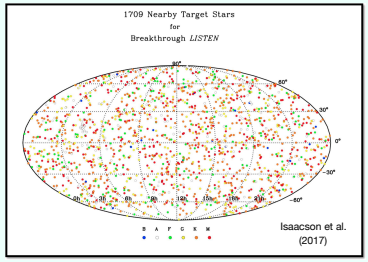


Figure 2. The frequency distribution for all the hits produced by the search pipeline (light blue), hits after initial cuts using criteria 1 and 2 from the Results section (dark blue), and the most significant hits which pass all the criteria (orange).

Enriquez et al. (2017)

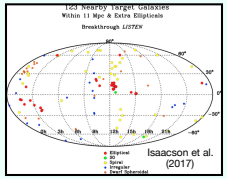
Target Selection

By prioritizing nearby stars, BL is sensitive to very low intensity signals that travel only a short distance to the Earth. Beyond 5pc, all spectral types are considered, and main sequence comprise the majority of the targets.



Isaacson et al. (2017)

BL is focused on nearby stars of all spectral types, across the entire celestial sphere. A smaller number galaxies are also included in the current target list.



Isaacson et al. (2017)

Instrumentation

At radio frequencies, the capability of the data recording system directly determines survey speed, and given a fixed observing time and spectral coverage, they determine survey sensitivity as well. Breakthrough Listen has the ability to write data to disk at the rate of 24 GB per second. Using commodity servers and consumer class hard drives, the BL backend can record 6 GHz of bandwidth at 8 bits for two polarizations. In a typical 6 hour session, the raw data recorded to disk can exceed 350 TB. Using GPU processors the data volume is reduced to 2% of the raw data volume in less than 6 hours.

The Drake Equation

$$N_b = R^* F_s F_p F_e n_{hz} F_b L_b.$$

SETI and Habitability

One of the guiding principles in SETI, the Drake Equation, has as one factor, the number of habitable planets per star. In the last 15 years, we have made immense progress determining, Eta-Earth, the frequency of Earth sized planets around other stars. In the next 15 years, we will be able to constrain the number of habitable planets per star, putting us one step closer to understanding our place in the Galaxy and if we have company.

References

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- Enriquez, J. E., et al. The Breakthrough Listen Search For Intelligent Life: 1.1-1.9 GHz Observations Of 692 Nearby Stars, arXiv:1709.03491 (2017)
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- Tellis, N. & Marcy, G. A Search for Laser Emission with Megawatt Thresholds from 5600 FGKM Stars, AJ, 153.251T, (2017)