OPEN ACCESS

A Radio Technosignature Search of Six Resonant Sub-Neptunes Orbiting HD 110067

Carmen Choza[1], Steve Croft[1,2,3], Andrew P. V. Siemion[1,2,3], Sofia Sheikh[1,2], Matthew Lebofsky[2], David H. E. MacMahon[2], Jamie Drew[4], and S. Pete Worden[4]

Published January 2024 •

Research Notes of the AAS, Volume 8, Number 1

Citation Carmen Choza *et al* 2024 *Res. Notes AAS* **8** 37

DOI 10.3847/2515-5172/ad235f

[1] SETI Institute, 339 Bernardo Ave, Suite 200, Mountain View, CA 94043, USA

[2] Breakthrough Listen, University of California, Berkeley, 501 Campbell Hall 3411, Berkeley, CA 94720, USA

[3] University of Oxford, Department of Physics, Denys Wilkinson Building, Keble Road, Oxford, OX1 3RH, UK

[4] The Breakthrough Initiatives, NASA Research Park, Bld. 18, Moffett Field, CA 94035, USA

Carmen Choza https://orcid.org/0009-0008-0662-1293

Steve Croft https://orcid.org/0000-0003-4823-129X

Andrew P. V. Siemion https://orcid.org/0000-0003-2828-7720

Sofia Sheikh https://orcid.org/0000-0001-7057-4999

Matthew Lebofsky https://orcid.org/0000-0002-7042-7566

1. Received January 2024
2. Accepted January 2024
3. Published January 2024

Exoplanets; Technosignatures; Search for extraterrestrial intelligence; Radio astronomy

Abstract

We describe archival observations and analysis of the HD110067 planetary system using the Green Bank Telescope (GBT) as part of the Breakthrough Listen search for technosignatures. The star hosts six sub-Neptune planets in resonant orbits, and we tune the drift rate range of our search to match the properties of the system derived by Luque et al. Our observations cover frequencies from 1 to 11.2GHz, using the GBT's *L*, *S*, *C*, and *X*-band receivers, to an equivalent isotropic radiated power limit of $\sim 3 \times 10^{12}$W. No technosignatures were found, but this unusual system remains an interesting target for future technosignature searches.

← **Previous** article in issue
Next article in issue →

1. Introduction

Using observations from NASA's Transiting Exoplanet Survey Satellite (TESS) and the ESA's CHaracterising ExOPlanet Satellite, Luque et al. (2023) discovered that the star HD110067 has six sub-Neptune planets, all of which orbit their host star in a stable resonant chain. As the brightest star known to have at least four planets, with all planets in a remarkably ordered orbital configuration, HD110067 offers an unprecedented opportunity to study the orbital evolution of planetary systems and the atmospheric compositions of sub-Neptunes. Three of the planets have low densities which suggest large, hydrogen-rich atmospheres. Sub-Neptune planets are one of the most common types of exoplanet discovered to date, so the question of whether they could support liquid water is crucial for target prioritization in the Search for Extraterrestrial Intelligence. Planned biosignature searches of sub-Neptunes are complementary to technosignature searches such as that described in this Research Note.

HD110067 (TIC347332255) is a bright K0-type star with a mass about 80% that of the Sun, located at $12^{\mathrm{h}}39^{\mathrm{m}}21\overset{\mathrm{s}}{.}50$, $20^\circ01'40\overset{''}{.}0$ (J2000). Breakthrough Listen (BL) is observing additional targets selected from the Exoplanet Follow-up Observing Program for TESS (ExoFOP-TESS) in addition to the nearby star sample described by Isaacson et al. (2017). HD110067 is valuable as a technosignature target not only because of its interest for biosignature searches. First, Earth views the system edge-on, which increases the likelihood of detecting radiation from any transmitters present whether intentional (Traas et al. 2021) or resulting from planet-to-planet transmissions which could be observed by their "spillover" during planet–planet occultations (Ashtari 2023); second, the large number of planets regardless of their position in the star's habitable zone increases the likelihood that an advanced civilization could have spread technology to neighboring planets, as has happened in our own solar system (Wright et al. 2022).

This search is one of a handful that cover such a broad range of frequencies, focused on a system with known properties that contains potentially habitable planets. We anticipate that this strategy will become more important as more exoplanet systems are characterized with next-generation telescopes.

2. Observations

BL observations at the Green Bank Telescope (GBT) typically employ a cadence strategy, observing a target ("on" source, "A") for five minutes and then an offset location ("off" sources; "B," "C," and "D") several beamwidths away, repeated three times for a 30minutes ABACAD cadence. Any signal detected by the search pipeline turboSETI is referred to as a "hit;" comparing the "on" and "off" scans helps us to eliminate nearby, intermittent radio frequency interference (RFI), as RFI is unlikely to be sky-localized or persistent. The BL backend records spectral data from several compute nodes simultaneously in 187.5MHz chunks, and produces multiple data products with distinct time and frequency resolutions, as described by MacMahon et al. (2018) and Lebofsky et al. (2019). The fine-frequency resolution spectra used for this search have a frequency resolution of ~2.79Hz and a time resolution of ~18.25s. Our observations consist of one ABACAD cadence at each of the *L*-, *S*-, *C*-, and *X*-bands of the GBT, observed beginning at UT 2022 April 12 08:35:37, UT 2020 May 23 04:50:01, UT 2020 May 16 04:08:14, and UT 2020

September 21 17:53:49 respectively. We note that the observations used in this analysis were archival, which indicates that there is potential for further similar searches in the BL data archive as more planetary systems of interest are identified. Observational parameters are recorded in Table 1.

Table 1. Survey Parameters

Receiver	Frequency	Hits	Events	$EIRP_{min}$	Maximum Drift Rate	max_drift
	(GHz)			(10^{12}W) [a]	($Hz s^{-1}$) [b]	
L	1.10–1.90	15,544	0	2.8–84.2	4.7	5
S	1.80–2.70	1965	0	3.2–190.8	6.7	10
C	4.00–7.80	2613	1	3.77–453.6	19.2	20
X	7.80–11.20	2528	0	4.2–758.1	27.6	30
Total	1.10–11.20	22,650	1	⋯	⋯	⋯

Notes.

[a] Minimum Equivalent Isotropic Radiated Power $EIRP_{min}$ (Enriquez et al. 2017) is a measure of the minimum necessary omnidirectional power of a transmitter at each receiver to be detected. Due to turboSETI's known drift-dependent sensitivity, the $EIRP_{min}$ values are recorded in ranges, with the lower bound corresponding to the $EIRP_{min}$ detectable for $\dot{\nu}_{unit} \leqslant 0.16 Hz s^{-1}$, and the upper bound corresponding to the $EIRP_{min}$ detectable at the highest drift rate searched. Sensitivities are calculated according to the turboSETI noise calculation correction factor described in Choza et al. (2023). [b] The maximum drift rate was calculated using the orbital semimajor axis of the innermost planet discovered in the HD110067 system, assuming a circular orbit; see Table1 from Luque et al. (2023).

3. Analysis and Discussion

We used turboSETI to search for narrowband signals with a signal-to-noise ratio (S/N) threshold parameter (ρ_{tseti}) of 10. In order to capture all possible drift rates that a narrowband radio transmitter associated with an HD110067 planet could exhibit when observed from Earth, we calculated the drift rate that would result from a transmitter positioned on the innermost planet, HD110067b, at the highest frequency observed in each band, following the work of Sheikh et al. (2019) and Li et al. (2023). The maximum drift rate calculated is due to orbital contributions only. The turboSETI parameter max_drift, which sets the range of drift rates searched, was chosen to overshoot the maximum drift rate at each band; both are recorded in Table 1.

Our search produced 22,650 total hits and one unique event in the *C*-band observation, at a frequency of 4072MHz. After plotting and visually inspecting the spectrograms, the signal is present in all three of the "off" scans at a lower S/N, consistent with our expectations for RFI. Therefore, we find no narrowband radio signals indicative of a transmitter located in the HD 110067 system above our search sensitivity threshold.

We calculated the minimum Equivalent Isotropic Radiated Power necessary for an isotropic beacon transmitter to be detected by our search with a five minute observation, using the distance reported by the NASA Exoplanet Archive, the procedure described in Equations (3)–(4) of Enriquez et al. (2017), and the GBT's System Equivalent Flux Density. The values are reported in Table 1. While we find no signals with this search, we anticipate returning to this system and others like it in the future with increasingly sensitive and diverse search methods.

Acknowledgments

BL is managed by the Breakthrough Initiatives, sponsored by the Breakthrough Prize Foundation. The GBT is a facility of the NSF, operated under cooperative agreement by Associated Universities, Inc.

Facility: Exoplanet Archive - .
