Real-time Technosignature Strategies with SN 2023ixf

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Abstract

Several technosignature techniques focus on historic events such as SN1987A as the basis to search for coordinated signal broadcasts from extraterrestrial agents. The recently discovered SN2023ixf in the spiral galaxy M101 is the nearest Type II supernova in over a decade, and will serve as an important benchmark event. Here we review the potential for SN2023ixf to advance ongoing techonsignature searches, particularly signal-synchronization techniques such as the "SETI Ellipsoid" that identifies over time stars that could transmit signals after observing a supernovae event. We find that more than 100 stars within 100pc are already close to intersecting this SETI Ellipsoid, providing numerous targets for real-time monitoring within ~3° of SN2023ixf. We are commencing a radio technosignature monitoring campaign of these targets with the Allen Telescope Array and the Green Bank Telescope.

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1. Introduction

Signal synchronization has long been discussed as a useful strategy for facilitating interstellar communication. In this framework, extraterrestrial agents would use noteworthy events such as galactic novae (Makovetskii 1977) or supernovae (Lemarchand 1994) to coordinate signal transmission. The "SETI Ellipsoid" is one such synchronization technique, which identifies an ellipsoid that grows over time with the Earth and the noteworthy astronomical event as foci, and the surface defined by light travel time. Stars that intersect the Ellipsoid surface have observed the event, and any potential synchronized signal from these stars would then be arriving at Earth. This approach provides an elegant solution for when and where to search for tecnhosignatures (Tarter 2001; Wright et al. 2018).

Davenport et al. (2022) recently reviewed the "SETI Ellipsoid" approach, noting that Gaia EDR3 parallaxes (Gaia Collaboration et al. 2020) enable precise predictions for when coordinated transmissions from nearby stars observing e.g., SN1987A would arrive. These approaches have been used recently to explore coordination with historic astronomical events (Nilipour et al. 2023, in press), and a range of sky surveys (Cabrales et al. 2023, in preparation). They are especially useful for coordinating observations around new events being actively observed by a wide range of facilities.

2. The SETI Ellipsoid for SN2023ixf

SN2023ixf was discovered near the spiral galaxy M101 on 2023 May 19 by Mr. K. Itagaki, [8] with the earliest detection from ZTF on 2023 May 17 (Bellm et al. 2019). At ~6.19Mpc (Mager et al. 2013), this is the closest Type II SNe in a decade, and is already generating excitement as a new benchmark core collapse event. As such, SN2023ixf offers a prime opportunity for real-time searches for coordinated technosignature signals.

Following Davenport et al. (2022), we have searched the Gaia 100pc star sample (Gaia Collaboration et al. 2021) for targets that are within 0.1 ly of the SETI Ellipsoid defined by SN2023ixf, which could plausibly broadcast a signal coordinated with the supernovae. SN2023ixf was discovered during its rise phase, and Type II SNe typically remain bright in the optical for several weeks. We have opted to use the discovery date of 2023 May 19 for our calculations. Our choice of a 0.1ly tolerance is motivated by both parallax uncertainties from Gaia, and the natural timescale of the SNe event. We find there are (as of MJD 60094) 108 stars within 0.1ly of this Ellipsoid, shown in Figure 1. As the light from SN2023ixf propagates, ~15 stars per week enter this 0.1ly sample, and the projected size of the Ellipsoid grows by ~2° per year.

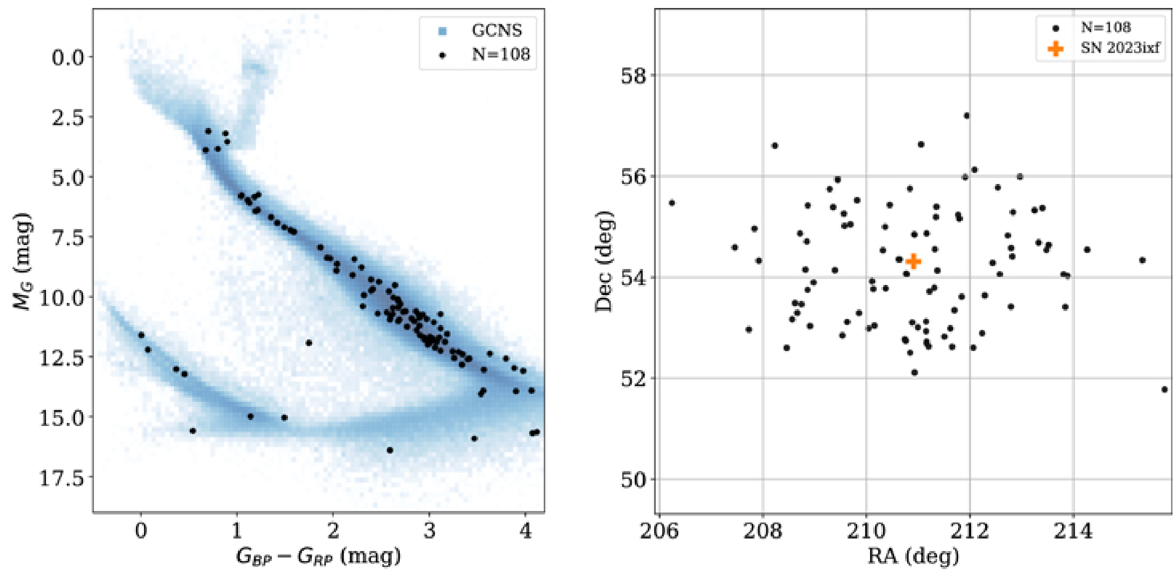

Figure 1. Left: Color–magnitude diagram for 108 stars within 0.1ly of the SETI Ellipsoid defined by SN 2023ixf as of MJD 60094 (black points), with the 100pc Gaia sample for reference (blue contours). These Ellipsoid-crossing targets already span a range of stellar types. Right: Sky positions for the Ellipsoid-crossing stars (black points), which lay in a ~3° region around SN2023ixf (orange cross).

3. Real-time Monitoring

SN2023ixf provides a unique opportunity to monitor the SETI Ellipsoid of a nearby supernova within weeks of its discovery. The Allen Telescope Array (ATA) is an ideal instrument for follow-up because it was designed specifically for radio technosignature searches: it has a wide instantaneous bandwidth, a large field of view, high spectral resolution beamforming capabilities from its log-periodic feeds, a design with a large number of small dishes (Welch et al. 2009), and a revamped state-of-the-art digital signal processing system. During the recent refurbishment of the array, dedicated time has been set aside for target-of-opportunity studies for technosignature applications (Perez et al. 2022), in addition to other astronomical follow-up (e.g., Bright et al. 2023).

We performed preliminary radio technosignature observations for 97 of the Ellipsoid-crossing main sequence stars with a two-beam survey using 20 6.1m dishes, covering 1.4GHz of bandwidth centered at 4.9GHz. These observations produced Stokes-*I* filterbank files with 1Hz spectral resolution and 15s time resolution, which will be searched with the turboSETI Doppler-drifting narrow-band technosignature search code (Enriquez & Price 2019).

Additionally, on 2023 May 31 we performed observations of the nearest (14.5pc) Ellipsoid-crossing star in the sample, HIP70497, using the *L*-band receiver at the Robert C. Byrd Green Bank Telescope; a second star in the sample, LHS6266, also fell within the GBT primary beam. Data were acquired using the Breakthrough Listen backend (MacMahon et al. 2018; Lebofsky et al. 2019) using Listen's standard observing mode, an ABACAD cadence with 5 minutes per position, following the procedure outlined by Franz et al. (2022) and others. Data will be processed with turboSETI.

We intend to revisit the Ellipsoid once a month for the next few months as new stars enter the sample, and are open to synchronizing our observations with other multiwavelength facilities.

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Footnotes

8 https://www.wis-tns.org/object/2023ixf