Astronomers scan the skies for nanosecond pulses of light from interstellar civilizations

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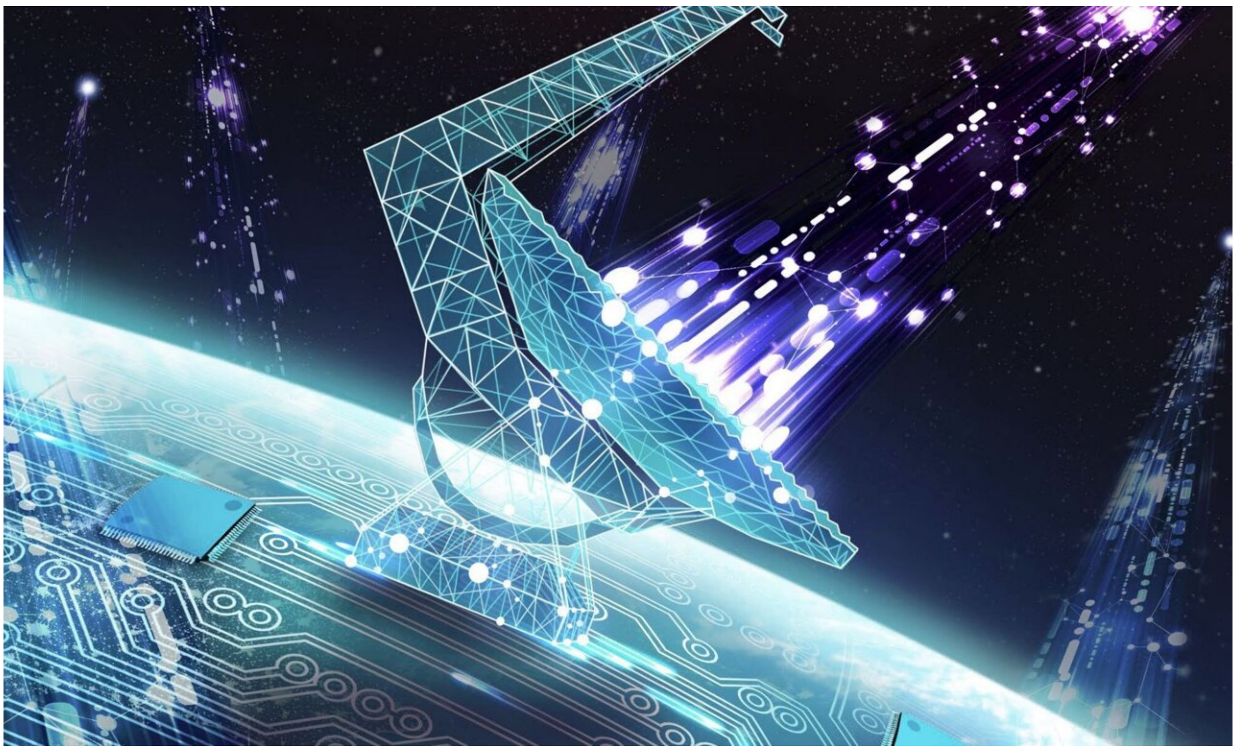

Artist's impression of Green Bank Telescope connected to a machine learning network. Credit: Breakthrough Listen/Danielle Futselaar

In 2015, Russian-Israeli billionaire Yuri Milner and his non-profit organization, Breakthrough Initiatives, launched the largest Search for Extraterrestrial Intelligence (SETI) project. Known as Breakthrough Listen, this SETI effort relies on the most powerful radio telescopes in the world and advanced analytics to search for potential evidence of technological activity (aka. "technosignatures"). The ten-year project will survey the one million stars closest to Earth, the center of our galaxy, the entire galactic plane, and the 100 galaxies closest to the Milky Way.

In 2018, they partnered with the Very Energetic Radiation Imaging Telescope Array System (VERITAS) Collaboration, a ground-based system of gamma-ray telescopes operating at the Fred Lawrence Whipple Observatory (FLWO) atop Mt. Hopkins in southern Arizona. In a recent paper, the VERITAS Collaboration shared the results of the first year of their search for "optical technosignatures" (from 2019 to 2020). Their results are a vital proof of concept demonstrating how future searches for extraterrestrial civilizations can incorporate optical pulses into their technosignature catalog.

The VERITAS Collaboration is an international effort that includes researchers from the FLWO, the Harvard-Smithsonian Center for Astrophysics (CfA), the Arthur B. McDonald Canadian Astroparticle Physics Research Institute, the Deutsches Elektronen-Synchrotron (DESY) research center, the NASA Goddard Space Flight Center, and multiple universities and research institutes. The paper that describes their findings, titled "A VERITAS/Breakthrough Listen Search for Optical Technosignatures," was recently accepted for publication in *The Astronomical Journal* and is available on the *arXiv* preprint server.

For the past sixty years, beginning with Project Ozma, the search for ETI has been almost exclusively focused on looking for evidence of radio transmissions. In recent years, scientists have been expanding the search to consider other potential technosignatures, which include directed-energy communications, radio and optical leakage from technological civilizations, infrared emissions from megastructures, spectral evidence for industrial pollutants in exoplanet atmospheres, and even spacecraft or debris in our solar system.

These and other potential examples of extraterrestrial technology were outlined in NASA Technosignature Workshop Report released in 2018. Incorporating the VERITAS array, which consists of four 12-meter (~40 ft) Cherenkov optical reflectors for gamma-ray astronomy, has allowed Breakthrough Listen to expand its search for optical technosignatures—specifically, for nanosecond optical pulses detectable over interstellar distances. Gregory Foote, a Ph.D. candidate with the Department of Physics and Astronomy at the University of Delaware (UD) and a co-author on the VERITAS paper, explained to Universe Today via email:

"While radio technosignatures have been traditionally looked for—we don't know which waveband the signal will come from or whether it will be pulsed or steady, so it makes sense to search in as many different ways as possible. The technosignature that we are looking for, a pulsed laser, can (in principle) be easily detected and transmitted over a distance of 1000 light-years using current technology. VERITAS itself allows us to search for these pulsed lasers using some of the largest telescopes on the planet."

Completed in 2007, the VERITAS array effectively complements NASA's Fermi Gamma-ray Space Telescope (FRGST)—and the Large Area Telescope (LAT) collaboration, of which Fermi is a partner—due to its larger collection area and greater sensitivity to gamma rays. In fact, VERITAS' segmented mirror telescopes—similar to the James Webb Space Telescope's (JWST) primary mirror—have the highest sensitivity of any telescopes in the very-high-energy (VHE) band, with a maximum sensitivity of 100 giga-electronvolts (Gev) to 10 tera-electronvolts (TeV).

These capabilities were tested as the Collaboration team searched through the Breakthrough Listen target catalog for signs of high-energy optical pulses. Said Foote:

"We began with the Breakthrough Listen target catalog released in 2017, then removed anything which was unsuited for VERITAS operation. This left us with around 506 possible targets, which were then ranked according to being close, dim, and other nice things—e.g., having exoplanets. This ranked list gave us a nice tool to select which ones to observe, as we just picked the highest-ranked ones which could be seen in a given month. We observed for 30 hours in total, with each observation lasting roughly 15 minutes. We ended up observing 136 targets, as there were a couple of observations that included multiple objects."

In addition, the Collaboration team examined VERITAS archival data going back to 2012. The team then calculated which targets from the Breakthrough Listen catalog were observed by VERITAS during the same period. Because they had limited computation time, they decided to spread the archival analysis across many different targets, analyzing only the first hour of quality data. "This left us with 249 observations of 119 non-overlapping fields containing 140 targets captured serendipitously," said Foote. "Unfortunately, we did not find evidence for this technosignature from these targets in any of the observations we analyzed."

While their analysis did not find evidence of any nanosecond optical pulses, the study has provided an important proof-of-concept that will inform future searches. It has also established limits on the number of stars that could be hosting transmitting civilizations, helping narrow these searches and increasing the likelihood of future detections. Beyond that, said Foote, this study could have significant implications for existing gamma-ray observatories and planned ones. This includes the Panoramic All-sky All-time Near InfraRed and Optical Technosignature

Finder (PANOSETI), which will conduct coordinated observations with the Veritas Observatory:

"I think the biggest impact on the broader field is that this technosignature can be searched for by piggybacking off of existing gamma-ray observatories, including VERITAS, and ones which have yet to be built. This also goes the other way too, as observatories being purpose-built for this technosignature, like PANOSETI, can have some gamma-ray science piggyback off of it. This is a unique intersection between fields which hasn't been greatly explored until now."

More information: Atreya Acharyya et al, A VERITAS/Breakthrough Listen Search for Optical Technosignatures, *arXiv* (2023). DOI: 10.48550/arxiv.2306.17680

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