DUAL SITE SETI USING LOFAR

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Overview

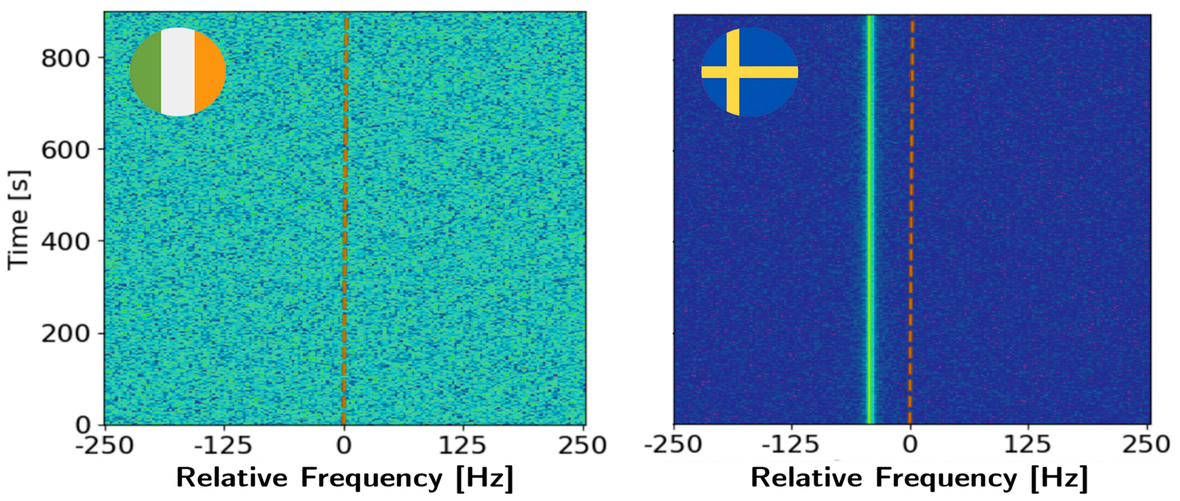
The Search for Extraterrestrial Intelligence (SETI) aims to search for evidence of **technosignatures** which can point towards the **possible existence of technologically advanced extraterrestrial life**. Radio signals might be used by other civilizations for various reasons. For over 60 years radio telescopes have been used to search for such technosignatures. However, the lower-frequency part of the radio spectrum has **largely remained unexplored** as a large number of searches were primarily conducted near 1.4 GHz. Here, we report simultaneous dedicated-time **observations of over 3.1 million targets** in the northern sky using two **LO**w **F**requency **AR**ays in **Sweden** and **Ireland**. The survey is searching for narrowband signals that exhibit a Doppler drift. The survey is also able to **reject the presence of any transmitter with the output power equivalent of Kardashev Type-I societies** towards **half of our target pool**. This is done with the use of simultaneous observations, along with being among the very first low-frequency SETI searches, which also allowed for the first time the excellent opportunity of rejecting anthropogenic signals with the help of coincidence matching between Irish and Swedish stations.

LOw Frequency ARray (LOFAR)

- **Radio telescope network** consisting of thousands of **dipole antennas** distributed across **Europe**.
- This survey makes use of telescopes in both **Birr, Ireland** and **Onsala, Sweden**
- It operates in the frequency range of **10-240 MHz**, which is lower than the frequencies used by most traditional radio telescopes.
- LOFAR has a **wide field of view**, which means it can observe a large area of the sky simultaneously.
- Each of our observations covers **5.2 degrees²** of the sky!

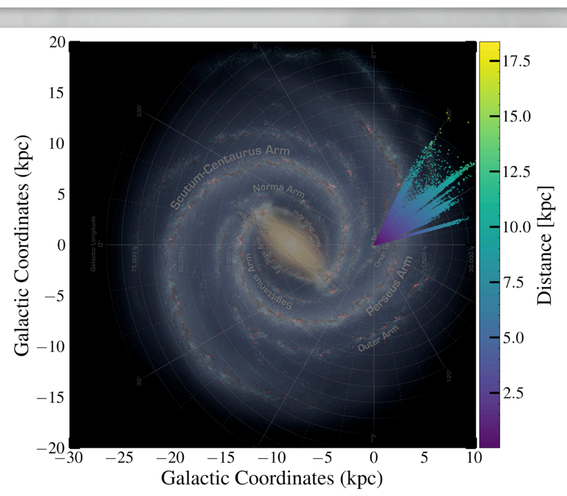
Narrowband Signals

- Narrowband signals are radio signals that **have a spectral width of <1 Hz**
- Narrowband transmissions are how we upload and download data from spacecraft. (e.g. the coherent downlink of Voyager 1 is ~8420.43 MHz)
- Due to the small spectral width of narrowband signals, they take **significantly less energy to propagate through space** than broadband signals. This makes them an appealing candidates to search for.
- On the downside, Earth is crammed with devices that use this method to communicate, such that observations are subject to a lot of **radio frequency interference (RFI)**!
- **Two LOFAR stations can be used to help reject false detections using**



The Future

- Continued dual-site observations
- Addition of more LOFAR stations like France!
- It's a big galaxy and an even bigger universe, let's get looking!

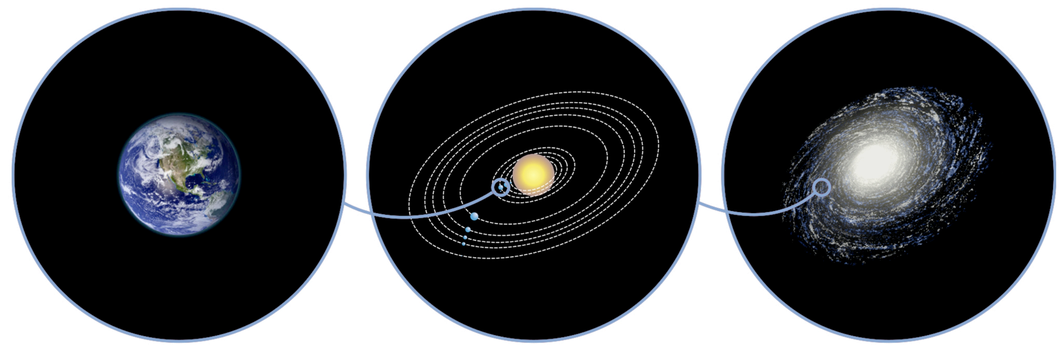


Kardashev Scale & Survey Sensitivity

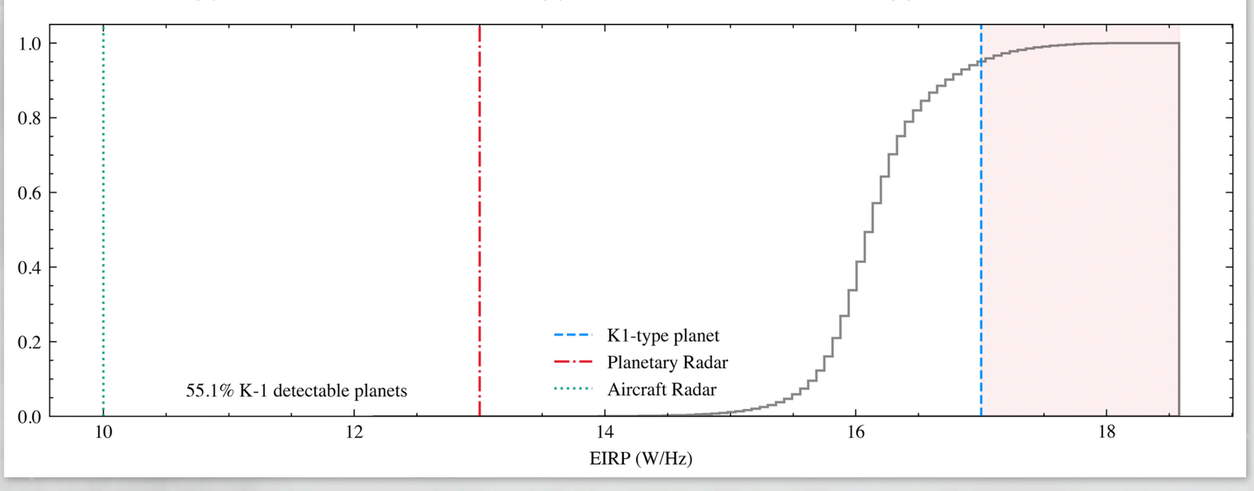
The Kardashev scale is a **measure of a civilization's technological advancement** based on its ability to harness and utilize energy.

Type I: Can harness all the energy available on its planet.
Type II: Can harness the energy of its entire star.
Type III: Can harness energy on a galactic scale.

Earth has a K-value of around **0.73**

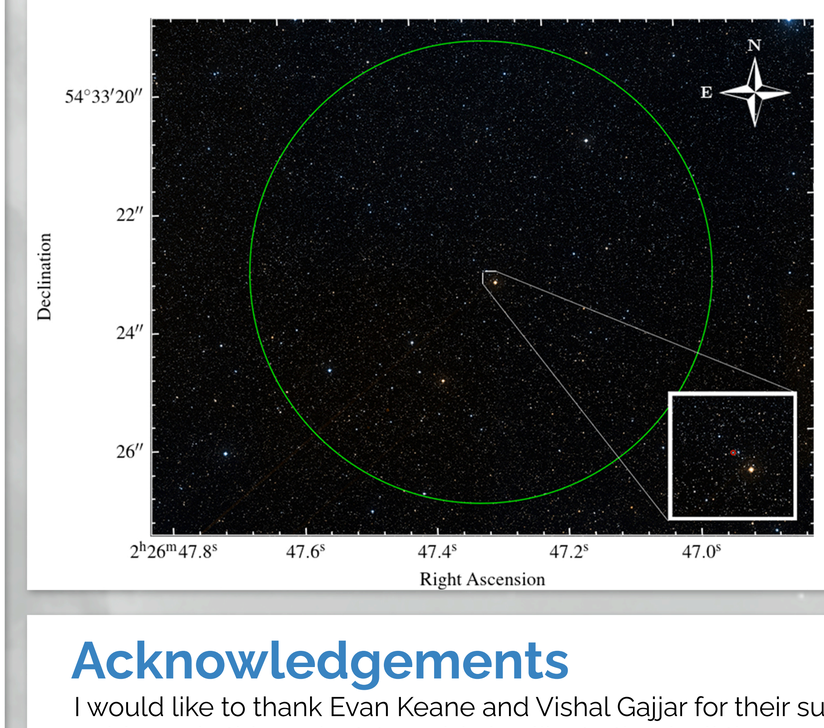


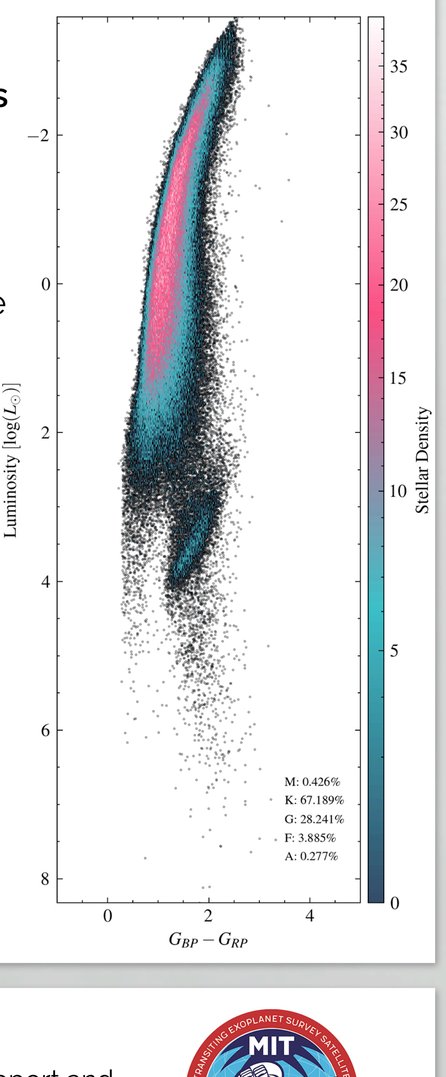
Type I: 10^{16} W *Type II:* 10^{26} W *Type III:* 10^{36} W



The Target Pool

- Observations are directed towards **TESS targets of interest.**
- LOFAR's beam happens to catch a **few more thousand** Gaia stars during TESS observations (avg. ~70,000)
- The majority of stars observed are **K and G**-type stars





Acknowledgements

I would like to thank Evan Keane and Vishal Gajjar for their support and guidance in this project. I would also like to thank all the members of the UC Berkeley Center Research center for their prior and continuous support. I'd also like to thank Tobia Carozzi for his efforts in running the dual site observation campaigns. Breakthrough Listen is managed by the Breakthrough Initiatives, sponsored by the Breakthrough Prize Foundation. The Onsala Space Observatory national research infrastructure is funded through Swedish Research Council grant No 2017-00648. This project includes data collected with the TESS mission. Funding for the TESS mission is provided by the NASA Explorer Program. STScI is operated by the Association of Universities for Research in Astronomy, Inc., under NASA contract NAS 5–26555. This work has made use of data from the European Space Agency (ESA) mission Gaia, processed by the Gaia Data Processing and Analysis Consortium (DPAC). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the Gaia Multilateral Agreement.

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