A Systematic Search of the Nearest Stars for Exoplanetary Radio Emission: Strong Radio Bursts from ROSS 614 AB

Daniel Winterhalter[1], Mary Knapp[2], Tim Bastian[3]

[1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA
[2]Massachusetts Institute of Technology, Cambridge, MA, USA
[3]National Radio Astronomy Observatory, Charlottesville, VA, USA

1. Introduction

Radio observations have been used as a tool to search for exoplanets since before the confirmed discovery of the first extrasolar planet. However, to date there have been no definitive detections of exoplanets in the radio regime. In 2016/17 we have started to conduct a blind (in terms of frequency) radio survey of the nearest star systems for exoplanetary radio emission with the VLA and LOFAR observatories. The goal of the survey is to obtain meaningful upper limits on radio emissions from (or modulated by) sub-stellar companions of the nearest stars.

2. The Nearest Stars

The selection of the “Nearest Stars” targets was guided by two considerations. First, while star systems close and far have been searched for radio emissions, a systematic survey of the nearest ones is lacking. Since any emission will, of course, fall off rapidly with distance, those from the nearest emitters would be strongest. Second, all of the nearest stars are M Dwarfs and Brown Dwarfs, star types known to be very active. Stellar activity is an advantage in observing anticipated magnetospheric emissions, as is shown in our Observing Probability study [1].

We thus are undertaking deep and unbiased ("blind") stares at the 10 nearest star systems observable with LOFAR’s Low Band Array (LBA), and the National Radio Astronomy Observatory’s (NRAO) Very Large Array (VLA). We undertake this survey without preconceptions of what magnetic fields may be present on exoplanets, or are modulated by them. The goal is to obtain, at least, a good upper limit (on the order of 10 mJy) on any radio emission produced by or modulated by the nearest exoplanets, covering a wide frequency range, starting with LOFAR’s 30 – 80 MHz band, and reaching up with the VLA in the P, L, S, and C-bands (230 – 8,000 MHz).

3. Observations

Not all the targets have been observed yet, nor have has all the available data been fully analyzed. Of particular interest, however, are the results obtained from our VLA observations of ROSS 614 AB, a red dwarf UV Ceti flare binary star system with no known planetary companions, 4.13 pc away. The ROSS 614 preliminary results are presented here. The Ross 614 system characteristics are:

- M-dwarf binary system (M4-4.5 V, M4.5-6.5 V)
- Distance: 4.3 pc
- Orbital period of 16.6 years
- Member of the Pleiades Moving Group
- Flare stars (strong radio emission has been detected from the location of the system previously)
- No substellar companions detected to date

We observed the ROSS 614 system 10 times over a 4-month period, for approximately 21 minutes each time. Data was acquired in L and S bands, and the array was in C configuration. No emission was detected in three of the observations. Strong radio emission was detected in each of the first six VLA observations, as well as the eighth.

All six detections were moderately left-hand circularly polarized (~50%). The measured fluxes for the first six observations with detections vary from 1-7 mJy (Stokes I), while the last is ~ 350 μJy. The image noise floors are below 30 μJy for LS-band and 45-90 μJy for L-band, yielding a signal-to-noise ratio greater than 10 on the first six detections. The last detection is weaker, but still significant. The higher frequency, wider bandwidth LS-band observations have lower noise than the L-band observations, as expected.

The recovered position of each detected source was compared to the expected current position of Ross 614 AB, accounting for proper motion. All detected sources were consistent with Ross 614 AB within the synthesized beam width of the observation. The interferometric resolution was not sufficient to spatially separate the binary components, so both stars are within a synthesized beam. There are no known extragalactic sources in close proximity to the current location of Ross 614 AB, so the detected flux is likely from one or both of the stars in the binary.

There is no consistent spectral shape across all observations. The polarization fraction stays roughly constant within the error bars. Stellar radio emission is commonly interpreted on a dynamic spectrum plot (time vs. frequency), but the short duration of the observations in this campaign preclude typical dynamic spectrum analysis. Stellar radio bursts show complex, fine time-frequency structure throughout their evolution, so it is unsurprising that the spectra of the Ross 614 AB flare observations vary relative to one another.

4. References

[1] Garcia, R., Winterhalter, D., Knapp, M., and Majid, W.: "A Statistical Model for Determining the Probability of Observing Exoplanetary Radio Emissions", manuscript in preparation, 2017.