Searching for Low-Frequency Radio Emission from Young Stars and Exoplanets

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Abstract

We aim to detect or offer upper limits on low-frequency radio emission emanating from young stars and exoplanets. Utilizing data from the VLA Low-Frequency Sky Survey, we employed image stacking techniques to improve the sensitivity of detection to a level of ~10 mJy/beam. To date, no conclusive evidence for radio emission has been detected among our sample.

VLA Survey

The VLA Low-Frequency Sky Survey redux (VLSSr) is a survey of the northern hemisphere at 74 MHz, with an average sensitivity of ~0.1 Jy/beam (Lane et al., 2014). By extracting subregions centered on our targets from this survey, we obtain images for our rms noise-weighted stacking analysis.

Planetary Radio Emission

Numerous planets in our own solar system exhibit low-frequency radio emission. An empirical scaling law seems to exist between incident solar wind power and emitted radio power associated with the planet (Zarka, 2007). A corresponding relationship may exist in other planetary systems, motivating our search.

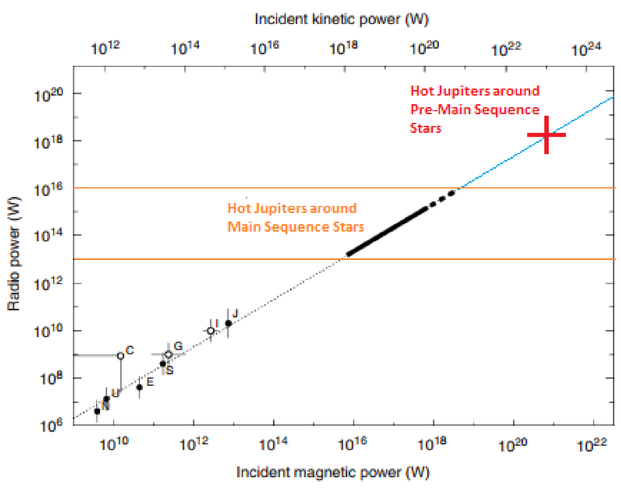
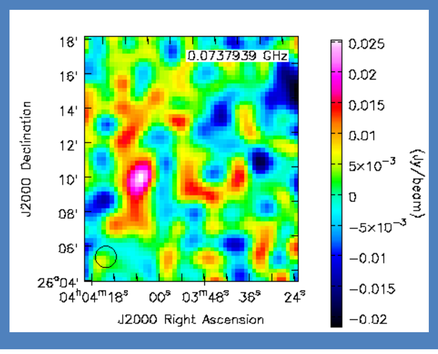


Figure adapted from Zarka, 2007

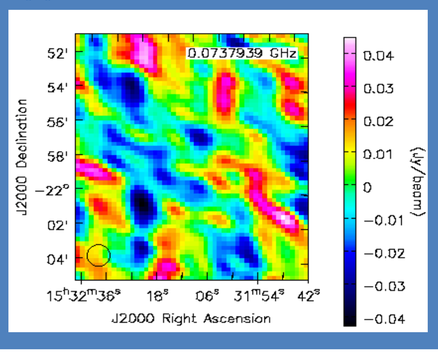
Emission from Young Star Forming Regions

Due to the increased stellar activity for pre-main sequence stars, we investigated samples of Class II and III young stellar objects (YSOs) in the nearby star-forming regions Taurus (334 objects, ~1-2 Myr old) and Upper Sco (116 objects, ~10 Myr old). Single target detection is unlikely due to beam collimation and time variability of the emission (Griessmeier, 2007), and direct comparison between VLSSr radio sources and the known YSOs yields no matches. On average, however, some emission may be detected, motivating our stacking analysis. Non-detections using this method gives us upper limits on radio emission of 6.5 mJy/beam for Taurus, 14.9 mJy/beam for Upper Sco, and 7.8 mJy/beam for the combined sample.

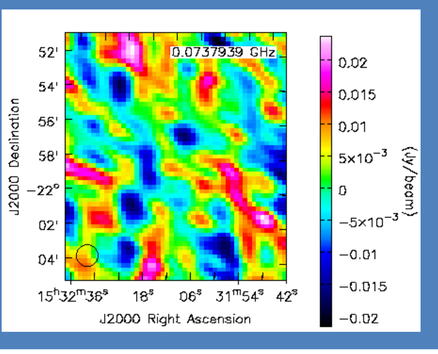
Taurus Stacked Emission



Upper Sco Stacked Emission

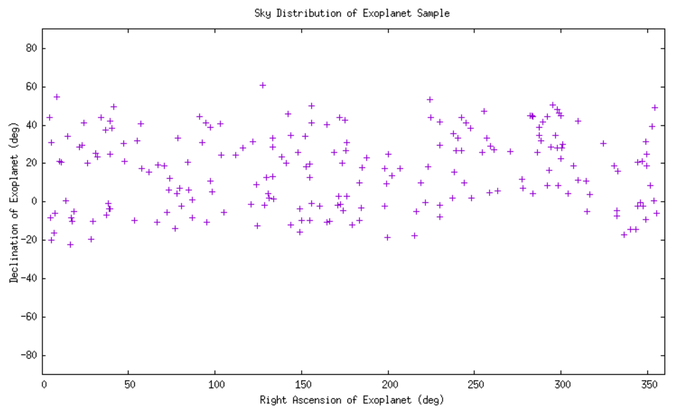


Combined Stacked Emission

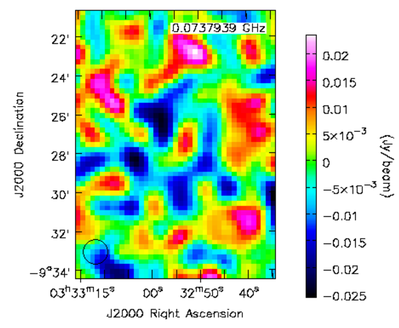


Radio Emission from Nearby Exoplanets

The exoplanets selected for our study consist of all known exoplanets (as of Jan. 2017) within 132 pc from the Earth. They are evenly distributed across the sky, limited by the constraints of the VLSSr. A non-detection for this sample gives an upper limit of 8.4 mJy/beam for emission.

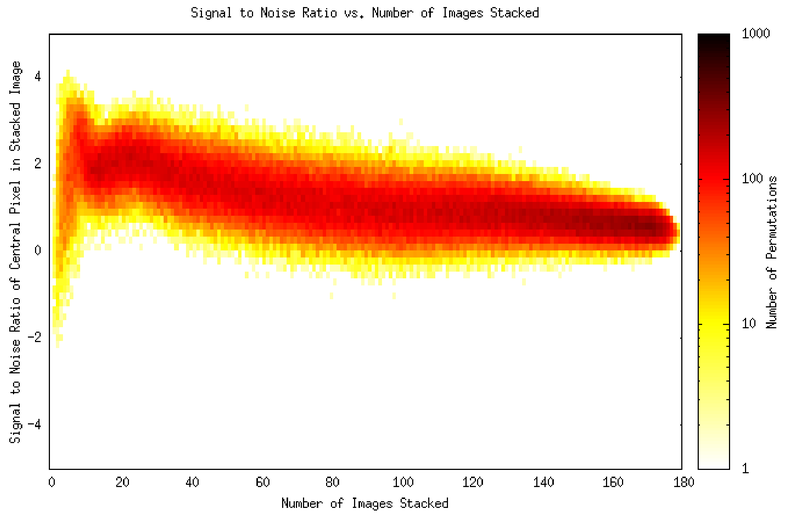


Stacked Emission



Ongoing Efforts

Since exoplanets are an inhomogeneous set, we have been stacking permutations of our sample to see if any subset shows emission. Using a Bayesian approach to sample the vast multitude of possible permutations, we impose a prior that goes as the inverse distance squared to account for the decrease in received flux. Evidence for emission would appear as a bump in the retrieved signal-to-noise-ratio vs. the number of images stacked.



References

Griessmeier, J. et al. 2007, A&A 475
Lane, W. 2014, MNRAS 440 (327)
Zarka, P. 2007, Planetary and Space Science 55 (5)