VLA P-Band Observation of Teegarden’s Star

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ABSTRACT

We investigate Teegarden’s Star (also known as GAT 1370, SDSS J023535.3+165255) for radio emissions caused by magnetic interactions between the star and its planetary system. This is one of 5 observations to be investigated in a survey that consists of nearby stars that are < 5 pc away. Teegarden’s star is a late M dwarf suspected of being a binary star with two planets that is thought to have masses of ~1.1 M⊕ each, with orbital periods of 4.04 days and 11.4 days. Being an M dwarf star, it has a strong magnetic field, but the magnetic field of its suspected planet is unknown which is where radio observations come into play. Planetary radio emissions will be evident through excited charged particles in the planet’s atmosphere, and/or planetary magnetic field interactions with solar wind. Observational data from the VLA in the P Band (0.23 – 0.47 GHz, 90 cm) and Teegarden’s star’s strong magnetic field allows for a reasonable ground-based survey. The Very Large Array (VLA) observed Teegarden’s star on August 16, 2016, within the time of 11:21:00 – 11:24:41 (~4 minutes) on the same day. With NRAO’s Common Astronomy Software Applications (CASA), we were able to calibrate and image the P Band data - imaging is taken a step further by imaging the different spectral windows and then by time frames. In our process, we did not find any radio emissions from Teegarden’s star but have established an upper limit on P Band radio flux from the system.

BACKGROUND

Radio emissions are a form of non-thermal emission that arise from charged particle-magnetic field interactions which can occur from planet-star interaction. Electrons are ejected from the star through solar wind and are attracted and accelerated towards planetary magnetic poles by the power of cyclotron maser instability (CMI) emissions. The impact of the electrons from the solar wind and dependent on the distance of the planet from the star in the Radiometric Goddard’s Law which states the relationship between solar wind power and planetary radio emission [1]. To the Radiometric Goddard’s Law, the planet absorbs the power contained in the electrons from the solar wind and a fraction of that power gets converted into radio flux which gives off a radio emission. So, the closer a planet is to the star the more the solar wind will have a larger power impact which gives off more radio flux and radio emission.

To be able to observe these emissions from exoplanets, we would like to establish a fundamental understanding of the planet and the strength of the planet’s magnetic field [2]. Also, with periodic observations, the rotation periods the planet can be accurately defined.

Teegarden’s star was discovered in 2003 and was referred to as a high-popper motion star (HPMS) that is a main-sequence star with the spectral type M5V [3]. In that time, Teegarden’s star was one of 7 stars with proper motions > 5 “/yr and ranked thir in the list of nearest stellar systems [4]; has detected two planets around Teegarden’s star that have a minimum mass of 1.1 M⊕, with orbital periods of 4.04 days and 11.4 days.

RESULTS & DISCUSSION

Catalogue Cross Matching

Table 1: Information about Teegarden’s star from MAST, Gaia DR1, and [1]. Teegarden’s star has a well-calibrated [1].

To get an accurate read on Teegarden’s star, sub-images from each of the spectral window and time window images were made then we took the rms value of each image to create upper limit plots.

SPECTRUMS & LIGHTCURVES

Upper Limits by Frequency

Upper Limits by Time

CATALOGUE CROSS MATCHING

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Now that we have our cleaned image, we can extract sources from our image by putting it through the Python Blob Detector and Source Finder (PyBDSF) to find out what objects were detected. Then, we can cross match the extracted sources with all sky surveys, gather the common sources and then flag, and then against each other to obtain a full list of common sources. With the common sources list, we can apply the appropriate shape for extragalactic sources, we can assume the spectral shape of the common sources’ fluxes. PyBDSF extracted ~900 sources from the cleaned image.

With a search radius of 1” (synthetic beam size) and a max distance of 26’ (synthesized beam size) out from Teegarden’s star, we were able to flag sources with the following all sky surveyings using VLA’s X-MC C:

- VLA-Low Frequency Sky Survey (ULS) at 14 MHz
- VLA Sky Survey (VSS) at 1.4 GHz
- The GJRTT All Sky Radio Survey (GATS) at 150 MHz

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RESULTS & DISCUSSION

In this observation, we did not find any radio emissions from Teegarden’s star.

Though, there are 4 more observations of Teegarden’s star in the P Band to be calibrated and imaged. The work done in this observation will serve as a framework with reusable script for doing the same analysis on the other observations.

References: