Cold giants around M dwarfs: rare gems or unseen multitudes?

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I am searching light curves from the *TESS* and *K2* missions for **long-period (P>20 days) planets** orbiting **M dwarf stars** to constrain the **occurrence rate** of their coldest planets and find targets for **future characterization.**

Scientific Motivation

Study the demographics of cold planets orbiting M dwarfs

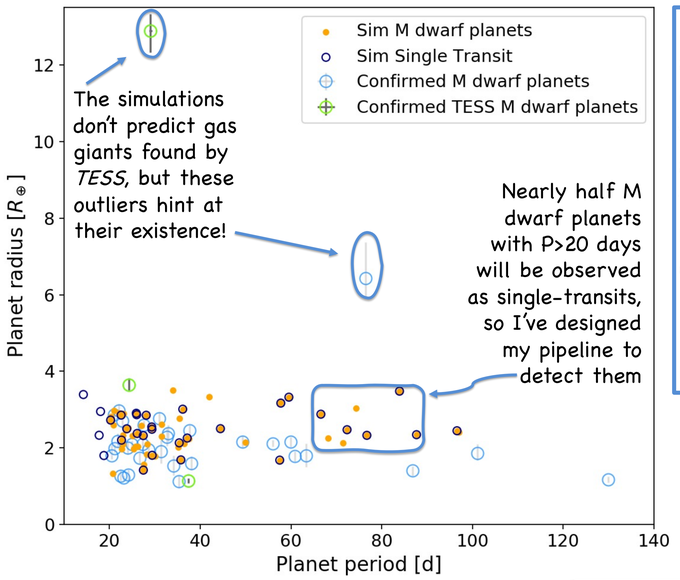
- *TESS*'s sample of low-mass stars is **larger and brighter** than past space-based missions which, paired with ***TESS*'s all-sky observing strategy**, provides a relatively **complete sample of M dwarf stars**
- *K2*'s **longer observing campaigns** will allow me to **extend the period range of this search,** improving my chances of finding transiting planets beyond the snow lines (where water freezes) of large M dwarfs
- I can **create a more robust estimate of the prevalence of cold planets** in M dwarf planetary systems than past calculations derived from *Kepler's* M dwarf sample (only 4000 stars, all Vmag>15!)

Determine the frequency of gas giants around low-mass stars

- Though the core accretion theory **predicts few gas giants around low-mass stars,** microlensing and radial velocity (RV) surveys **have found several cold Saturns and Jupiters** orbiting M dwarfs
- *TESS's* survey strategy provides a comprehensive study of nearby M dwarfs, allowing me to place **constraints on the frequency** of cold giant planets **even in the event of a null detection**

Find candidates for mass and atmospheric characterization

- *TESS* will be the first mission to provide targets largely accessible for mass and atmospheric characterization
- Studying the atmospheres of cold M dwarf planets could **inform theories of planet evolution and gas giant formation**
- Any gas giants we find will be **ideal targets for RV and atmospheric follow-up**, contributing to questions on evolution and formation of cold gas giants



I use the Barclay et al. 2018 simulations (Sim) to estimate the yield of this project as ~27 single-transiting and ~32 multiply-transiting M dwarf planets with P>20 days from the *TESS* primary mission.

Approach

Pipeline

- I have designed a **pipeline** to find both single- and multiply- transiting planets from *TESS* light curves **using the Box Least-Squares algorithm**
- I will use the **injection/recovery method** to determine the **completeness of my pipeline**

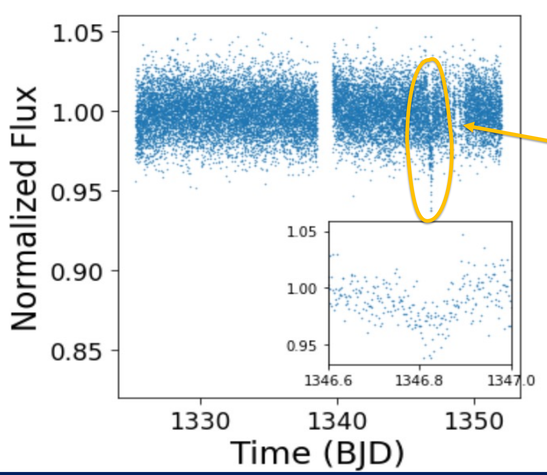
Vetting

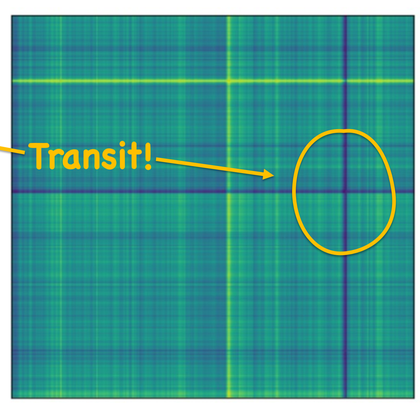
- I am designing a **convolutional neural network (CNN)** to quickly and efficiently vet targets
- To maximize the effectiveness of the CNN, I am using a novel technique of **converting light curves into Gramian Angular Difference Fields (GADF)** to **better distinguish planet transits from false positives**

Follow-up

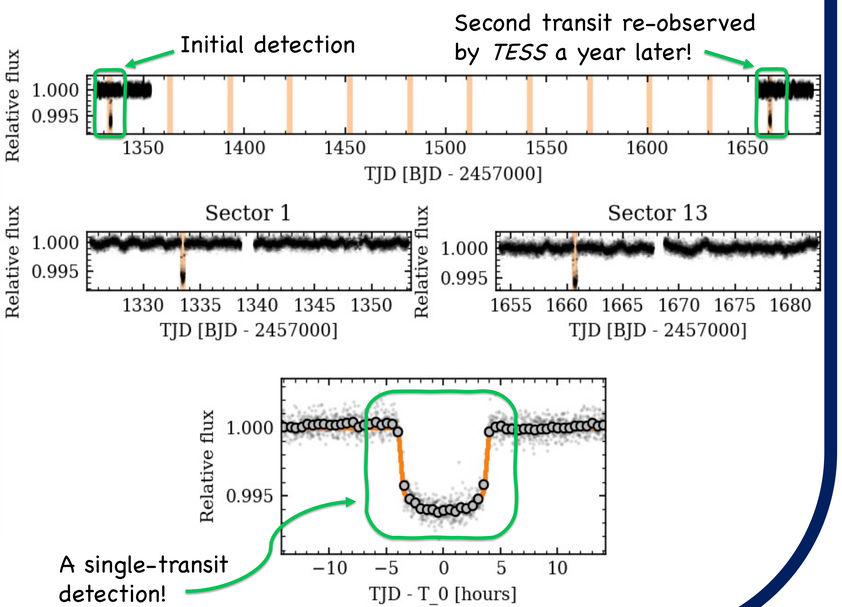
- *TESS's* extended mission will **re-observe many planet candidates** (PCs) **including some found by *K2* along the ecliptic,** constraining the orbital periods of single-transiting PCs and reducing the error in those of multiply-transiting PCs
- I will also follow up using ground-based photometric and spectroscopic facilities to better **constrain the true periods of single-transiting targets and validate/confirm PCs**

GADFs represent the temporal correlation between points in the time series and allow me to employ computer vision techniques to better recognize and characterize patterns (like transits) in light curves





While this light curve does not depict an M dwarf orbiting planet, it does show a *TESS* single-transit event as well as how the extended mission will recover additional transits



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