Hundreds of Thousands of Eclipsing Binaries from the TESS Full Frame Images

Ethan Kruse

@ethan_kruse ethan.kruse@nasa.gov

NASA Goddard Space Flight Center

with Brian Powell, Veselin Kostov, Jeremy Schnittman, Elisa Quintana

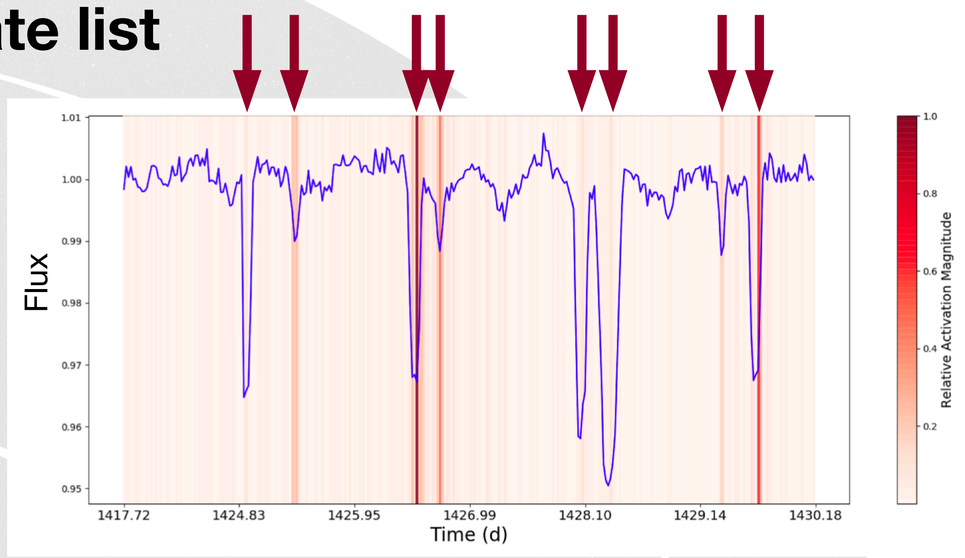
Project Goal

- Search tens of millions of FFI light curves for eclipsing binary (EB) signals
- Create an EB catalog with well-vetted EBs, removing blends/false positives

1. Use machine learning to create initial EB candidate list

- We created light curves for all ~50 million stars brighter than 15th mag in the TESS FFIs using a local version of eleanor (Feinstein et al. 2019).
- We then trained a neural network to detect eclipse-like signals in all the light curves to create **a list of 470,000 candidate EBs.**

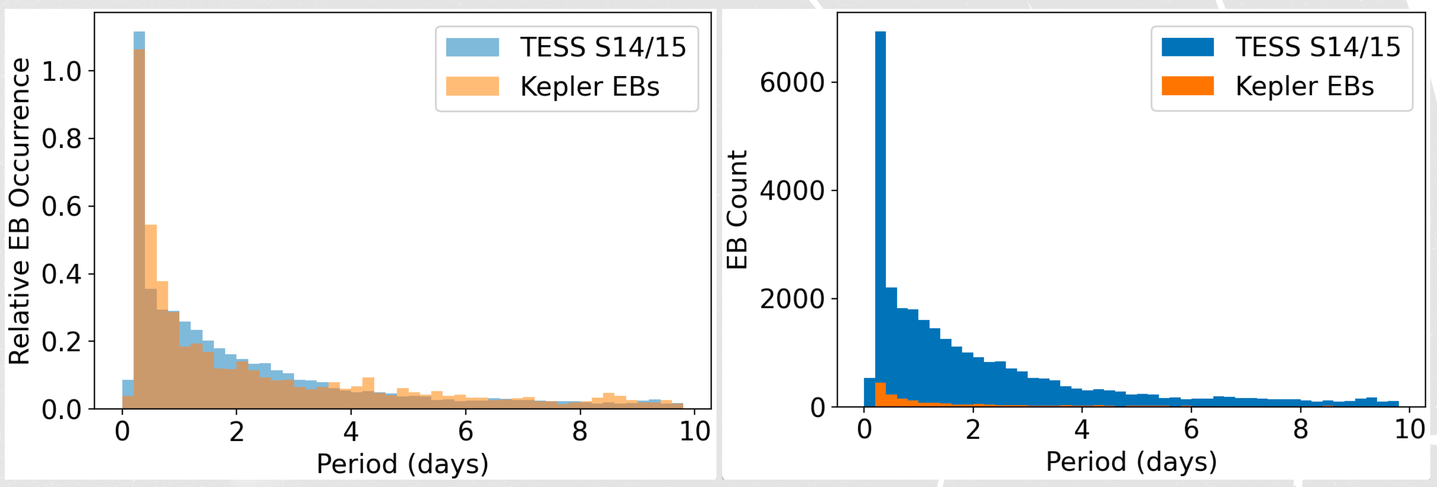
The figure on the right shows the neural network saliency map for a sample light curve: the arrows and red bands indicate where the network strongly activates, lining up with real eclipses and demonstrating successful training.



2. Run period finding and eclipse fitting to get system parameters

- We ran QATS (Kruse et al. 2019) on the candidate EBs to get periods and fit the traditional eclipse parameters

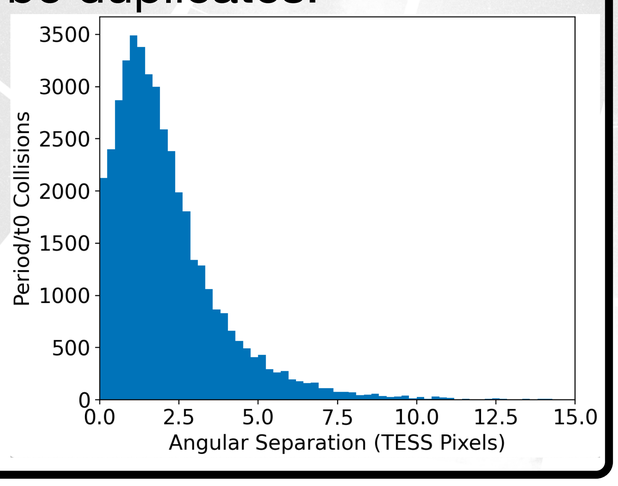
Left panel: the relative period distribution of our smaller practice set of 20,000 EBs from sectors 14 and 15 (blue) compared to the 2,000 Kepler EBs (orange).
Right panel: Raw counts binned by period of our practice set of 20,000 EBs from sectors 14 and 15 (blue) compared to the 2,000 Kepler EBs (orange).
The full 470,000 S1-26 catalog will be in our paper in prep.



3. Vet the candidate EBs and remove false positives

- TESS's large pixels cause blending and allow a single EB signal to be present in multiple light curves.
- We're combining period and ephemeris collision matching with more sophisticated vetting to create a well-vetted catalog of EBs.
- Overall about 1/3 of the candidate EB signals in our initial list appear to be duplicates.

The vast majority of period and ephemeris collisions occur between stars within a few pixels of each other, shown by the separation distribution on the right.



Conclusions

- We found ~470,000 candidate EBs in the S1-26 TESS FFIs
- About 1/3 are duplicates due to blending in TESS's large pixels
- Our upcoming catalog of ~300,000 EBs will be larger than Kepler's catalog by a factor 150.