Vetting TESS Exoplanet Candidates and Refining Their Transit Predictions

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When transit exoplanets pass in front of their parent stars, they produce periodic but faint dips in the star's light curve. To schedule follow-up observations with ground-based telescopes and space observatories it is essential to know exactly when these transits occur. Discovery catalogs like the TESS Objects of Interest (TOI) catalog originally publish these predicted ephemerides. Unfortunately, over time the precision of these ephemerides is known to worsen as the errors in the orbital period accumulate across many revolutions. An initial uncertainty of only a few minutes at discovery can grow to deviations of several hours after just a few years. However, precise ephemerides are critical for scheduling follow-up observations on expensive facilities like JWST. In this work I developed a pipeline that refines TESS ephemerides by fitting individual transits across multiple observation sectors and implemented a machine learning classifier to separate true exoplanets from false signals such as eclipsing binaries. I then applied the pipeline to 377 TESS Objects of Interest, where 19,506 individual transits were fitted, resulting in a median precision 4.2 times better than current catalog values. Planets with shorter orbital periods showed the highest refinements, exceeding thirteenfold improvements. Also, the classifier reached 95.9% accuracy when tested on 2,616 annotated samples. To confirm the real-world reliability of the improved ephemerides, I compared the results against 125 verified exoplanets with published periods, finding a median difference of just 645 milliseconds, with 76% matching within five seconds. This system will streamline observation scheduling, and similar methods could be adapted for thousands of remaining TESS candidates needing characterization.

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