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Simultaneous Observations of the Northern *TESS* Sectors by the Zwicky Transient Facility

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Article information

The *Transiting Exoplanet Survey Satellite* (*TESS*) (Schliegel 2017) is a powerful facility for studying a broad range of astrophysical objects. The Zwicky Transient Facility (ZTF) (Bellm et al. 2019; Graham et al. 2019; Masci et al. 2019) is conducting a nightly public survey of all 13 *TESS* northern sectors in 2019–2020. ZTF will observe the portions of the current *TESS* sector visible from Palomar Observatory each night. Each ZTF pointing will have one exposure each with *g* and *r* filters, totaling two

images per night. The first northern sector, Sector 14, was observed from 2019 July 18 to August 15. The observations of the second northern sector, Sector 15, began on 2019 August 15. The majority of Sectors 14 and 15 have been covered by ZTF, except for a portion of *TESS* Camera 4, due to the visibility limits. ZTF is also making additional nightly *g*- and *r*-band observations of denser stellar regions (e.g., near the Galactic Plane) to better facilitate variability studies of Galactic objects.

ZTF has a FOV of 55.0 square degrees and a light-sensitive area of 47.7 square degrees within that FOV. A *TESS* sector can be completely covered with about 60 ZTF fields. ZTF has 1'' pixels (2'' PSF) compared to the *TESS* 21'' pixels (50% enclosed flux). Consequently, ZTF observations will allow identification of transient and variable sources within a *TESS* pixel, particularly important if more than one source contributes to the variable flux. In addition, ZTF goes deeper than *TESS*, having a median 5σ limiting magnitude of 20.6 in *r*-band and 20.8 in *g*-band. This allows the identification of weak sources that may be contributing to the *TESS* measured flux. See Figure 1 for an example of ZTF and *TESS* images of the same field. ZTF *g*- and *r*-band measurements will complement *TESS* 600–1000 nm observations, allowing estimates of temperature and other spectral characteristics. See the comparison of spectral bands in Figure 1. ZTF saturates between $m \sim 12$–13.

Figure 1. The sky coverage of *TESS* for the first 2 years of observations. The color indicates how many days an area is observed by *TESS*. The ZTF-fields that cover *TESS*-sector 14 are over-plotted in red. In the lower left, the filter response curves are shown, green and red indicate ZTF *g* and *r*, black shows the *TESS* bandpass. The pictures on the lower right show a ZTF image, a *TESS* image of the same area, and a simulated *TESS* images based on the ZTF image using Tractor.

ZTF will release data from *TESS* fields in three forms: in addition to the

nightly alerts distributed by established ZTF brokers, nightly alerts converted to JSON format are distributed via ZTF's bucket on Google Cloud as a tarball (Duev 2019), and monthly photometric light curves also distributed via Google Cloud. Because ZTF alerts are issued nightly, they can identify transient and variable sources that are active, allowing ground-based follow-up by the community on a prompt timescale, faster than the timescale on which *TESS* data is typically available. Initial results are provided in earlier ATELs (Burdge et al. 2019; Yan et al. 2019).

Details on how to access alerts and light curves are given in a Jupyter notebook accessible, e.g., via Google Colaboratory (Duev 2019). ZTF–*TESS* alerts are cross-matched against several external catalogs, including 2MASS PSC, AllWISE, IPHAS DR2 and *Gaia* DR2. Finally, we note that no filtering is applied to the ZTF–*TESS* alerts prior to their public release. We encourage spectroscopic followup of alert candidates as quickly as possible to maximize the potential science return from the ZTF–*TESS* observations. In addition, supernova candidates identified using a combination of automated filters and human vetting by the ZTF collaboration are automatically posted to the Transient Name Server[8] with the "sender" keyword set to "ZTF_TESS."

ZTF light curves for all objects observed concurrently by *TESS* and ZTF will be available publicly less than one month from the end of a *TESS* sector observation campaign. Details on how to access and filter the ZTF light curve data will be given in the same Jupiter notebook as mentioned above. More functionality to work with ZTF light curve data will also be available with subsequent light curve releases.

Tractor (Lang et al. 2016) models of ZTF images can be used to simulate the overlapping *TESS* observations. This technique exploits the higher resolution of ZTF to resolve the position and intensities of sources that may be blended in *TESS* images. The modeling software used to produce co-added ZTF images and simulated *TESS* images corresponding to the *TESS* fields is available on Github (Lang 2019a, 2019b). Example code and detailed documentation for ZTF/*TESS* modeling will be disseminated in the coming months.

ZTF is a project led by PI S. R. Kulkarni at Caltech, and includes IPAC; WIS, Israel; OKC, Sweden; JSI/UMd, USA; UW, USA; DESY, Germany; NRC, Taiwan; UW Milwaukee, USA, and LANL USA. ZTF acknowledges the

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Footnotes

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