The K2-TESS Stellar Properties Catalog

Keivan G. Stassun\textsuperscript{1,2}, Joshua A. Pepper\textsuperscript{3,1}, Martin Paegert\textsuperscript{1}, Nathan De Lee\textsuperscript{4,1}, Roberto Sanchis-Ojeda\textsuperscript{5}

ABSTRACT

We introduce a catalog of stellar properties for stars observed by the Kepler follow-on mission, K2. We base the catalog on a cross-match between the K2 Campaign target lists and the current working version of the NASA TESS target catalog. The resulting K2-TESS Stellar Properties Catalog includes value-added information from the TESS Target Catalog, including stellar colors, proper motions, and an estimated luminosity class (dwarf/subgiant versus giant) for each star based on a reduced-proper-motion criterion. Also included is the Guest Observer program identification number(s) associated with each K2 target. The K2-TESS Stellar Properties Catalog is available to the community as a freely accessible data portal on the Filtergraph system at: http://filtergraph.vanderbilt.edu/tess_k2campaigns.

1. Introduction: K2 and the Need for a Stellar Properties Catalog

The Kepler telescope was launched in March 2009 and delivered photometry for \(\approx 200,000\) stars, all located in the same field between Cygnus and Lyra (Borucki et al. 2010; Burke et al. 2014). The main Kepler mission operated for about 4 years until after a second reaction wheel failed, such that the telescope could no longer be pointed at the original field with sufficient pointing stability. A new mission concept, K2, was then initiated (Howell et al. 2014), in which the telescope is pointed at the ecliptic plane with a new field observed along the ecliptic every three months. K2 should permit discovery of small transiting exoplanets orbiting bright stars, as initial tests show that K2 is capable of photometry with a precision of 20–50 parts per million for thousands of stars in each field (e.g., Vanderburg & Johnson 2014).

It is expected that the community will play a major role on the success of the K2 mission. In particular, the target stars to be observed in each K2 field—or Campaign—are selected from community proposals, and for the first three fields (Campaigns 0–2) the total number of targets has ranged from 7,000 to 21,000 stars. The brightest and the coolest dwarfs represent two of the most requested types of targets, together with very massive stars, known eclipsing binaries, and stars in open clusters. With the first K2 data releases, the Kepler team has provided coordinates and Kepler magnitudes for all selected stars, but the provision of stellar properties is left as a community endeavor. With this document, we describe an online data portal that aims to provide estimated stellar properties of a large fraction of stars in each K2 Campaign, based on a work-in-progress target catalog that is being developed by the NASA TESS\textsuperscript{3} science team. Our hope is that this resource will serve the community for optimizing the science return of the K2 mission, such as organizing followup observations of K2 targets of interest, for a variety of scientific investigations.

\textsuperscript{1}Vanderbilt University, Nashville, TN 37235; keivan.stassun@vanderbilt.edu
\textsuperscript{2}Fisk University, Nashville, TN 37208
\textsuperscript{3}Lehigh University, Bethlehem, PA 18015
\textsuperscript{4}Northern Kentucky University, Highland Heights, KY 41099
\textsuperscript{5}Massachusetts Institute of Technology, Cambridge, MA 02139

\textsuperscript{1}Transiting Exoplanet Survey Satellite (TESS) information is available at: http://tess.gsfc.nasa.gov.
2. The TESS Target Catalog

The Transiting Exoplanet Survey Satellite (TESS; Ricker et al. 2014) has been selected by NASA for launch in 2017 as an Astrophysics Explorer mission to search for planets transiting bright and nearby stars. During its two-year mission, TESS will monitor at ∼1-minute cadence at least 200,000 main-sequence dwarf stars with \( I_C \approx 4-13 \) to search for planetary transits.

To optimize the TESS target stars for planet detection, the TESS Science Office’s target selection working group (TSWG) is developing a catalog of bright dwarf stars across the sky, from which a final target list for TESS can be drawn based on in-flight observation constraints yet to be determined. The basic consideration is to assemble a list of dwarf stars all over the sky in the effective temperature \( T_{\text{eff}} \) range of interest to TESS, bright enough for TESS to observe, and taking extra steps to include the scientifically valuable M-dwarfs. The overall approach is to first combine several all-sky star catalogs to serve as the basis for the target catalog, and then augment that with smaller valuable catalogs. We then apply cuts to select stars of the desired ranges in apparent magnitude and spectral type, and to eliminate evolved stars.

We use the 2MASS point source catalog as the starting point, since it is the one catalog that exists across the full range of magnitudes for TESS targets for the entire sky. We cross-match the 36,597,875 2MASS stars having \( J < 13 \) against the NOMAD, Tycho2, Hipparcos, APASS, and UCAC4 catalogs. The cross-match is done based primarily on position (1 arcsec tolerance). We also include smaller catalogs of nearby high-proper-motion M-dwarfs. That combined dataset is the Augmented TESS Target Catalog (ATTC), which at the time of this writing contains 35.8 million stars.

We use color-\( T_{\text{eff}} \) relations to derive \( T_{\text{eff}} \) from the available optical and infrared colors. There are a variety of empirical color-\( T_{\text{eff}} \) relations available. Currently we use \( T_{\text{eff}} \) relations from Casagrande et al. (2008, 2010). We calculate \( T_{\text{eff}} \) for each target star in multiple ways and adopt as the best estimate the value with the smallest formal error. The scheme adopted for calculating \( T_{\text{eff}} \) is graphically summarized in Figure 1.

Since spectroscopically determined surface gravities are not available for most stars in the ATTC, we use the reduced proper motion (RPM) statistic, which Collier Cameron et al. (2007) found to be useful for separating giant stars from dwarfs. Note that the RPM method does not robustly disambiguate subgiants \((3.5 < \log g < 4.1)\) from dwarfs \((\log g > 4.2)\), so they will be included in the dwarf group. However, the method cuts at about \( \log(g) = 3.5 \). For all targets in the ATTC that have recorded proper motions, \( \mu \), we compute \( \text{RPM}_J = J + 5 \log \mu \). According to this method, stars with \( \text{RPM}_J \) less than an empirically-determined cut in \( \text{RPM}_J \) vs. \( J-H \) parameter space are taken to be non-giants, i.e. either dwarfs or subgiants. We conservatively flag stars that are within \( 2\sigma \) of the \( \text{RPM}_J \) threshold as possible giants. Figure 2 illustrates the separation of K2 stars into giants and dwarfs/subgiants according to the \( \text{RPM}_J \) cut.

3. The K2-TESS Stellar Properties Catalog

We have cross-matched the ATTC (see Sec. 2) against the stars observed in all K2 Campaigns\(^2\) (as of this writing this includes Campaigns 0–2). Since the K2 target stars have mostly been drawn from the EPIC

\(^2\)K2 Campaign target lists obtained from: http://keplerscience.arc.nasa.gov/K2/Fields.shtml.
catalog\textsuperscript{3}, and since the Campaign 0 Engineering Run target list\textsuperscript{2} included target coordinates that were not specified with the precision of the EPIC coordinates, we matched the ATTC directly to EPIC through RA and Dec coordinates (1 arcsec tolerance). We then select from that overall cross-match the observed K2 campaign stars by their EPIC IDs. We do not include in the released K2-TESS catalog 3,264 stars from K2 Campaign 2 that do not have EPIC coordinates (these are mostly custom apertures for open clusters and solar system objects). The current cross-matched catalog for Campaigns 0–2 includes 26,825 stars with $J < 13$.

In addition, while not part of the planned TESS Target Catalog, we have also matched the K2 target stars against all fainter 2MASS and UCAC4 stars in order to provide an additional cross-matched “faint extended” K2-TESS catalog for $J > 13$. We caution that this faint extended catalog is provided as-is. In particular, the performance of the RPM giant/dwarf separation, and of the color-$T_{\text{eff}}$ relations, have not been as carefully vetted for these fainter stars.

The K2-TESS Stellar Properties Catalog for $J < 13$ and the faint extended K2-TESS catalog for $J > 13$ are available through the Filtergraph data portal system (Burger et al. 2013) at a dedicated URL: http://filtergraph.vanderbilt.edu/tess_k2campaigns. Figure 3 gives an example map display utilizing the portal, and Table 1 gives a listing of the data fields included in the catalog.

| Field name | Description |
|------------|-------------|
| 2massname  | Object identifier from the 2MASS catalog |
| ra, dec    | Right ascension and declination from 2MASS catalog |
| glong, glat| Galactic longitude and latitude from RA and Dec. |
| ucacname   | UCAC4 catalog identifier |
| tcname     | Tycho catalog identifier |
| hipname    | Hipparcos catalog identifier |
| k2name     | K2/EPIC target catalog identifier |
| k2camp     | K2 Campaign number during which target was observed |
| J, H, K    | Apparent $JHK$ magnitudes from 2MASS |
| V          | Apparent $V$ magnitude from Vsrc |
| Vsrc       | Catalog source of $V$ magnitude |
| Verr       | Reported error on $V$ magnitude from Vsrc |
| pmra, pmdec| Proper motions in RA and Dec from UCAC4 catalog |
| isdwarf    | Flag indicating 1 for likely dwarf/subgiant, 0 for likely giant, based on RPM$_J$ criterion |
| teff       | Estimated $T_{\text{eff}}$ based on color-$T_{\text{eff}}$ relation using photometry from teffsrc |
| teffsrc    | Catalog source of photometry used to derive $T_{\text{eff}}$ (teff) [see Fig. 1] |
| tefferr    | Propagated uncertainty on $T_{\text{eff}}$ (teff) |
| kepmag     | Apparent magnitude in the Kepler bandpass, taken from EPIC catalog |
| investids  | K2 GO ID numbers associated with target (multiple IDs separated by ‘|’)

Table 1: Description of fields in the K2-TESS Stellar Properties catalog and K2-TESS faint extended catalog.

The K2-TESS Stellar Properties catalog is being provided as a service to the community. We intend to regularly update the catalog on the Filtergraph data portal as additional K2 Campaign targets are observed. The data portal website includes fair-use terms and contact information.

\textsuperscript{3}The K2 Ecliptic Plane Input Catalog (EPIC) available at: https://archive.stsci.edu/k2.
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Fig. 1.— Flowchart summarizing the calculation of $T_{\text{eff}}$ in the TESS Target Catalog. In order to best estimate $T_{\text{eff}}$ for a given star, we calculate $T_{\text{eff}}$ values using a variety of different methods from Casagrande et al. (2010), although we are in the process of evaluating other methods. The blue and green methods cover the majority of stars, whereas the pink methods are for cool stars. If a star’s color is outside of the valid range for the method, the $T_{\text{eff}}$ is not computed for that method. The algorithm described here prefers the $T_{\text{eff}}$ method with the smallest formal error, while avoiding common problems with incorrect magnitudes in some source catalogs.
Fig. 2.— We adopt the reduced-proper-motion diagram of Collier Cameron et al. (2007) to separate stars into likely giants (red) versus likely dwarfs (blue). Note that subgiants are generally mixed in with the putative dwarfs.
Fig. 3.— Example map displays of all stars with $J < 13$ from the K2-TESS catalog on the Filtergraph data portal system. (Top) Full map showing Campaigns 0–2. (Bottom) Zoom of one campaign.