Characterizing the Variability of Blazars using the TESS Mission

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With the supervision of Dr. Carini of the WKU Physics department I have been researching the variability of blazars utilizing the TESS mission and validating different publicly available, python-based, data reduction pipelines. Blazers are a form of radio loud Active Galactic Nuclei (AGN) that are feeding super-massive black holes. They emit relativistic jets with a constant continuum seen face-on from Earth. Thus the emission observed is dominated by the flux produced from the work of the relativistic jets, and making its host-elliptical galaxy appear as a point source. With blazars I look for characteristics within their optical variability on rapid timescales.

The Transiting Exoplanet Survey Satellite (TESS) is an on going mission that primarily search stars for exoplanets, yet a community led program allows for requests of studying other objects. TESS captures each hemisphere in 26 sectors defined as 24x90 degree rectangles stemming from the equator to the poles where it will observe a single sector for 27 days. TESS produces data in both 30 second and 2 minute cadences. Primarily utilizing the 30-second cadence data I have classified 87 separate blazars as either variable or non-variable. This is done by downloading publicly accessible sector data from TESS.-cut for a desired object in the form of a 30x30 Target Pixel File (TPF). Some of these objects may only include a singular sector of data and thus only been observed for nearly a month. While other blazars may have been observed in multiple sectors. Thus allowing for a continuous study of the object for nearly an entire year as the sectors begin to overlap as the observation carries to the elliptic poles in what are called Continuous Viewing Zones (CBVs). Each target includes background flux that must be corrected in order to observe the true variability of the blazar. The original data set of 87 blazars were reduced using the in-house created "Simple Differential" method, where 10 of the darkest pixels were picked as the flux background within the TPF, and the average flux values were subtracted from the raw flux values of the pixels containing the blazar. Later within the research, other more automated pipelines were utilized to provide comparison. These data reduction pipelines consisted of the following: Three different pipelines from the NASA Light-curve corrector class (Regression, Co-trending Basis Vectors (CBV), and Pixel Level Decorrelation (PLD)), Quaver developed by Dr. Krista Smith in collaboration with SMU, and eleanor Background Subtraction developed by Dr. Adina Feinstein (Feinstein et al. 2019, PASP, 131, 1003.)

Due to the nature of these data reduction methods, as well as reoccurring anomalies within the TESS data, cross referencing of ground based data along with the reduction methods is ideal. For ground based data, the Zwicky Transit Facility (ZTF) database was utilized for simultaneous data to over-plot and verify each light curve. Yet not all objects had simultaneous ground based data. Thus, 10 targets were selected to be reduced using all 6 methods and over plotted with simultaneous ground based data. Following investigation and over plotting of these 6 methods it was found that only Simple Differential, Quaver, and eleanor adequately corrected for background and instrumental systematics as they agreed with ground-based observation.

In conclusion, beginning in May 2021 I have created light curves and classified 87 blazars with all currently released TESS data. I found 33 objects to be varying, 29 non-varying, and 25 possibly varying. 10 of these varying targets were reduced using 6 different methods and cross-referenced with ZTF data, where It was revealed that only 3 methods appropriately reduce the light curves. Now, with confidence in the accuracy of the produced light curves, characterizing the light curves by constructing and fitting power spectral densities has been completed. Showing, that in the majority of the 10 targets observed, despite which of the three methods used (Simple Differential, Quaver, or eleanor), the light curve will appear similar and inherently have relatively the same percent change in variability during TESS's observation.