EPSC Abstracts
Vol. 13, EPSC-DPS2019-620-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Temporal Phenomena in Comet 46P/Wirtanen as Observed by the TESS Spacecraft

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Abstract

Comet Wirtanen spent 27 days within the field of view of the TESS spacecraft, from 20 September to 17 October 2018. During this time, 1288 images of the comet were obtained at a 30-minute cadence, and background stars were removed to allow a detailed analysis of the temporal behavior of the comet. Photometry, measured from the images reveal a previously unreported moderate-sized outburst, in which the comet brightened by 0.6 mag on 26 September. Coadding the images into 5-day bins also shows that Wirtanen has a previously unknown dust trail. Analyses of the data are continuing, and we will report on these and other results.

1. Introduction

Comet 46P/Wirtanen is an inherently interesting object for a number of different reasons: it is one of a small number of hyperactive comets, producing more water than expected for its nucleus size; it is a near twin of the EPOXI mission target 103P/Hartley 2; and its orbit is such that it has a high likelihood of being selected as the target of a future spacecraft mission. Wirtanen's excellent 2018 apparition, which culminated in an historically close approach to the Earth (0.0775 AU) on 16 December, offered an opportunity to characterize the properties of this important object. During its approach to the Sun, Wirtanen remained within the field of view of the TESS spacecraft for 27 days while images were obtained every 30 minutes. We are using these high-cadence observations to investigate the temporal behavior of comet Wirtanen during this time period.

2. TESS Observations

The Transiting Exoplanet Survey Satellite (TESS) searches for extra-solar planets by staring at a sector of the sky for 27 days at a time, measuring the photometry of stars in the field to look for transits [2]. Stepping through a total of 26 sectors, TESS will observe over 90% of the sky over a two-year mission. One sector consists of observations from four cameras, each with a 24° field of view (21-arcsec pixels), that cover the sky from ±6° ecliptic latitude to the ecliptic pole. Year 1 of operations uses 13 sectors to cover the southern hemisphere, and year 2 will cover the North. Broadband (600-1000 nm) images are obtained every 2 minutes and then coadded into 30-minute exposures that are saved. Over the course of 27.4 days, as many as 1300 images are obtained of the sector. On occasion, comets fortuitously pass through the TESS field of view and we can use these high-cadence, photometric-quality observations to study the comets' temporal behavior. During Sector 3 observations from 20 September to 17 October, comet Wirtanen remained in the field of one of the TESS cameras, while 1288 images were obtained.

3. Background Removal

The TESS images are crowded with stars that must be removed to maximize the quality of the comet data. Initially we are adopting the TESS user-provided software *Difference Image Analysis* (*DIA*, [1]), which is designed to look for objects that vary in brightness with time. As part of the *DIA* procedures, the background stars and any scattered light are removed from each image, and we use these cleaned images for our comet analyses (Figure 1).

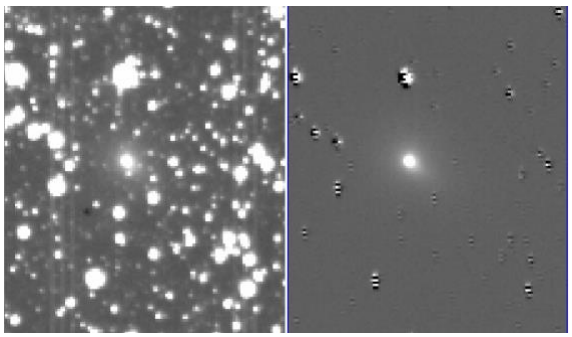

Figure 1: Example TESS field containing comet Wirtanen, before (left) and after (right) the removal of background stars using *DIA*.

4. A Well-Defined Outburst

Photometry measured from the TESS observations (Figure 2), shows a secular brightening of the comet over the 27 days of coverage (while *r* decreases from 1.51 to 1.30 AU). It also reveals an outburst that commenced on 26 September, with the coma brightening by 0.6 mag. This is the only outburst to be reported for this apparition of comet Wirtanen. The high cadence observations show a 2-phase brightening, with a rapid increase lasting ~1 hour, followed by a more gradual brightening that continued for another 8 hours. Examination of the images, enhanced by dividing out a 1/ρ profile, shows outburst material expanding outward with a velocity ~0.7 km/sec. After ~9 hours of brightening, the outburst contribution faded exponentially over the following ~20 days.

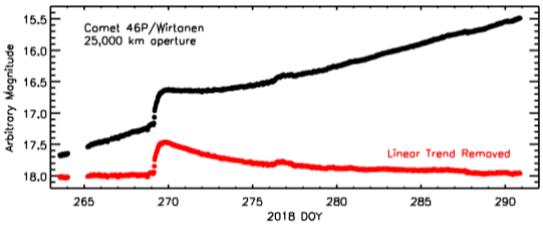

Figure 2: Photometry of comet Wirtanen measured in a fixed, 25,000 km radius aperture (black points). The 27-day secular brightening trend is seen, with a 0.6 mag outburst beginning on 26 September (DOY 269). A linear trend has been removed from the red points to highlight the outburst and its subsequent fading.

5. Wirtanen's Dust Trail

To investigate Wirtanen's coma and surrounding environment, we coadded images into 5-day bins. These combined images reveal that Wirtanen has a dust trail that has never before been reported (Figure 3). The orientation of this trail correlates with the comet's velocity vector, rotating by ~20°, as the viewing geometry changes over the 27 days of observations.

6. Summary

We used the long-duration, 30-minute cadence TESS observations of comet Wirtanen to explore the comet's behavior from 20 September to 17 October 2018. These data revealed two new discoveries: 1) Wirtanen experienced a moderately large outburst on September 26, brightening by 0.6 mag. The high-cadence of the measurements showed that the coma brightened in 2 phases. No other outbursts have been reported for comet Wirtanen in the 2018 apparition. 2) Wirtanen has a previously unknown dust trail that is revealed in coadded TESS images. We will report on these and other results.

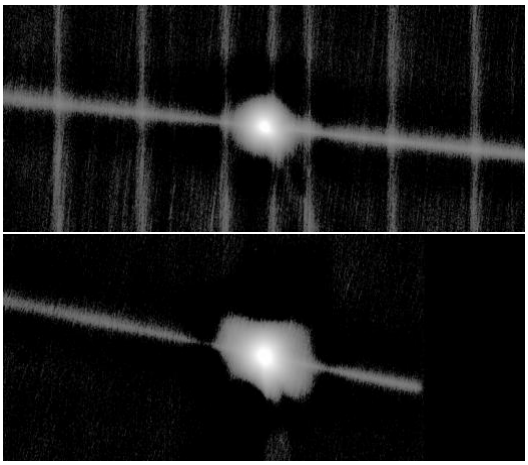

Figure 3: Coadded images from 28 September-2 October (top) and 13-17 October (bottom) showing Wirtanen's newly discovered dust trail. The trail rotates with time, reflecting the changing view of the comet's velocity vector. The odd shape of the coma and the "dropout" of the trail near the comet are artifacts introduced by oversubtraction of the background, which is caused by the presence of the comet itself. The vertical lines in the top panel are "strap" artifacts from the TESS CCD, not yet removed.

Acknowledgements

This paper includes data collected by the TESS mission, which are publicly available from the Mikulski Archive for Space Telescopes (MAST). Funding for the TESS mission is provided by NASA's Science Mission directorate.

References

[1] Oelkers, R.J. and K.G. Stassun, Astronomical Journal, 156:132, (2018).

[2] Ricker et al., 2015, JATIS, 1, 014003