COMPARING SMALL AND MEDIUM-SIZED OUTBURSTS OF COMET 29P

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Comet 29P/Schwassmann-Wachmann1(hereafter 29P) is a highly active member of the centaur population, notorious for its unusual outburst behavior. Hovering at large heliocentric distances, 29P is too cold for the sublimation of water ice to drive its outbursts. Despite the low temperatures, frequent outbursts of differing sizes have been observed for 29P. This unusually high frequency and magnitude of outbursts at such cold temperatures have left astronomers puzzled. With data collected from the Hubble Space Telescope (HST) during a medium-sized and a small-sized outburst of 29P, the differences between outbursts of two different magnitudes were explored. Understanding the differences between small and medium-sized outbursts of 29P can provide insight into how the characteristics of its outbursts scale with size.

Despite having an orbit and size consistent with an Asteroid, 29P has a composition and outburst behavior similar to that of a Comet, thus classifying it as a Centaur. Centaurs are small icy bodies with orbits between Jupiter and Neptune, which are thought to dynamically link the Jupiter-Family Comets (JFCs) to the Trans-Neptunian Objects (TNOs) of the outer solar system. Based on their composition and outburst behavior, many Centaurs, like 29P, are often referred to as both Comets and Centaurs. Although the outburst mechanism of most comets is the sublimation of water ice, 29P is too cold for its water ice to sublimate enough to drive an outburst. For this reason, the mechanism driving 29P's outbursts is currently unknown. However, what is known, is that 29P does exhibit frequent outbursts of various magnitudes.

The Target of Opportunity (ToO) observations collected with the HST were acquired following reports of a possible fragmentation event of 29P before Oct. 1st, 2019 [1]. The observing cadence captured 29P within two days of a 0.9 magnitude, and thus medium-sized, outburst. This set of observations provided data both preceding and following this 0.9 magnitude outburst, which would allow us to probe the development of the ejecta.

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Between the purported fragmentation event and the HST observations, 29P underwent two small outbursts of magnitude 0.4-0.5 on Oct. 7th [2] and Oct. 16th of 2019 [3], followed by the medium-sized 0.9 magnitude outburst around Oct. 19th, 2019 [4]. A timeline of the observation window, purported fragmentation window, and reported outbursts from August to October of 2019 is given in Fig. 1.

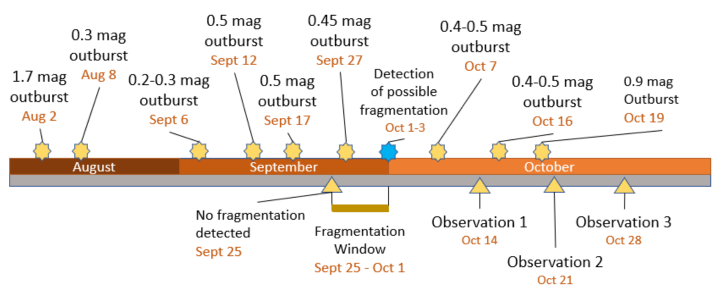

Fig. 1 Timeline of reported outbursts of 29P around the time of observation.

Three sets of observations were conducted using the HST in October of 2019. The first set is a collection of eight images on Oct. 14th, 2 in the F689M filter, 2 in the F845M filter, and 4 in the F487N filter. The second set is also eight images collected on Oct. 21st, using the same three filters and their respective number of images. The third set is a collection of 12 images on Oct. 28th, 4 in the F689M filter and 8 in the F350LP filter. Table 1 shows the wavelengths and corresponding colors of these 4 filters.

Table 1 Filters used for observations.

Filter	Range (nm)	λ_{eff} (nm)	Color
F689M	6450 - 7325	6873	Red
F487N	4828 - 4918	4874	Cyan
F845M	7895 - 9018	8431	Red-IR
F350LP	3197 - 10710	5558	Visible

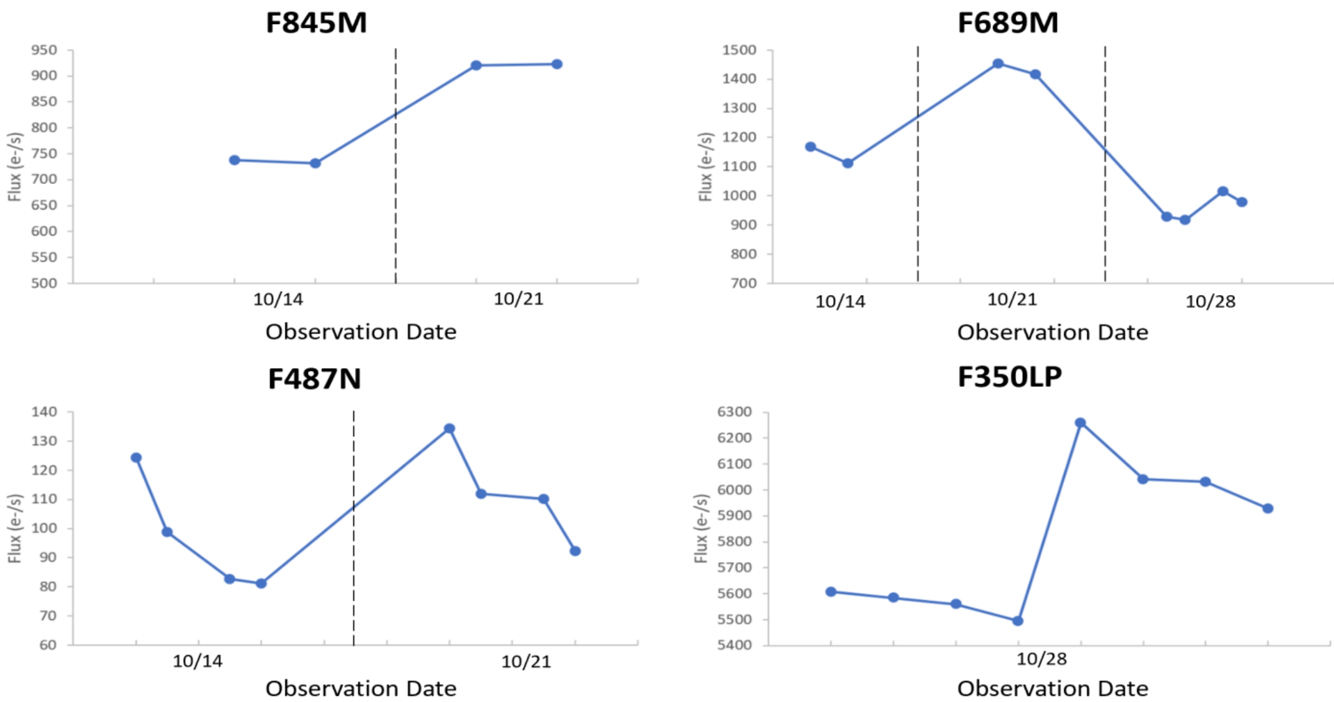

Fig. 2 Flux vs. Observation date for all 4 filters.

One of the most important pieces of information for characterizing and comparing comet outbursts is the flux. The flux is a measure of how much light from an object reaches the detector. A python script was written to calculate the flux of the comet within a 0.8-arcsecond aperture. The flux values were then separated into data subsets based on their respective filter, such that a plot of flux vs. time could be made for each filter (Fig. 2). These plots show a significant increase in the flux between Oct. 14th and Oct. 21st, which is consistent with the reported 0.9 magnitude outburst observed on Oct. 19th [1]. The significant increase in flux was observed in all three filters used across those two observation dates. There was a 26% increase in the Red-IR band, a 31% increase in the red band, and a 67% increase in the Cyan band. In addition to the 0.9 magnitude outburst occurring on Oct. 19th, a much smaller 0.2 magnitude outburst is thought to have occurred on Oct. 28th. As shown in the F350LP and F689M plots, a noticeable jump in the flux occurs between 12:40 and 13:40 on Oct. 28th. In the full visible spectrum, the flux increased by 18% within one hour before continuing to fall back down. This jump in the flux is also seen as an 11% increase in the red band filter.

Statement of Research Advisor

Johannes worked on the analysis of Hubble Space Telescope (HST) observations of an object far from the Sun that is continuously out-bursting. In his project, he developed a detailed timeline of various outburst events surrounding the HST observations, which provides important context for the interpretation of our data. He prepared the HST data by carefully removing cosmic rays contaminations, and by further processing the telescope images he isolated and analyzed the properties of the material ejected by different kinds of outburst.
- *Dennis Bodewits, College of Science and Mathematics*

References

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Authors Biography

Johannes J. Allen is a senior completing concurrent B.S. degrees in Aerospace Engineering and Physics at Auburn University. He has been conducting research in the Cometary Science research group at Auburn for the last two years. In addition to his research work, he is a Teaching Assistant for Physics and the president and co-founder of the Astronomical Society at Auburn Univ.

Youssef Moulane, Ph.D., is a postdoctoral researcher in the Physics department at Auburn University. He got his B.S. and M.S. in High Energy Physic & Astrophysics at Cadi Ayyad University in Morocco and his Ph.D. in Astronomy and Astrophysics at the University of Liege in Belgium. While getting his Ph.D., he also did research at Le Havre University in France and the European Southern Observatory in Chile.

Dennis Bodewits, Ph.D., is an Associate Professor in the Auburn University Physics Department. After getting his Ph.D. in Laboratory Astrophysics at the University of Groningen in the Netherlands, he worked as a Research Scientist at NASA Goddard Space Flight Center and the University of Maryland. He also has an asteroid named after him, “10033 Bodewits”!