EPSC Abstracts
Vol. 13, EPSC-DPS2019-992-1, 2019
EPSC-DPS Joint Meeting 2019

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

Hubble Space Telescope Cosmic Origins Spectrograph Observations of 46P/Wirtanen During Close Approach

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Abstract

The historic close approach of comet 46P/Wirtanen brought the hyperactive small body within 0.077 AU (12 million kilometers) of Earth on December 16th, 2018. This close approach presented the opportunity to directly study the inner coma (<100 km from the nucleus) of a comet, a region often not resolvable in Earth-based observations. We used the Hubble Space Telescope's Cosmic Origins Spectrograph to acquire far ultraviolet (FUV) spectra of the hyperactive comet from January 9 to 20, 2019. These FUV spectra of the inner coma will be compared to observations taken by the Alice ultraviolet spectrograph (UVS) on board the European Space Agency (ESA) *Rosetta* spacecraft.

1. Introduction

Comets are often thought of as the remnants of the early solar system. They are tossed from their frozen realm in the Kuiper Belt into the inner solar system by small perturbations and spend that short last portion of their life sublimating away in eccentric orbits around the Sun. Comets and their tails have been observed for thousands of years due to their striking appearance and large scale in the night sky, but some of the most intriguing and informative components about a comet are on scales ten thousands times smaller than the coma at large. Observations from the Alice ultraviolet spectrograph on board the ESA *Rosetta* mission to 67P/Churyumov-Gerasimenko found evidence of dissociative electron impact on $\sim$ 100 km scales around the nucleus when 67P was at large heliocentric distances [1]. Further observations revealed that dissociative electron impact became less important at small heliocentric distances [2], except during outbursts [3] or solar transient events [4].

The Rosetta results demonstrated that electron impact can be used as a remote plasma diagnostic, as a tracer of faint activity, and as probe to measure the abundance of gases otherwise unobservable. The main challenge is to define the conditions under which dissociative electron impact emission is a more effective process than fluorescence.

2. Observations

Observations of 46P/Wirtanen were taken by the Hubble Space Telescope Cosmic Origins Spectrograph and STIS instruments between January 9 and 20, 2019 with three goals in mind:

1. Identify the physical processes of the inner coma and search for dissociative electron impact emission.

2. Find the relative abundances of H_2O, CO_2, and CO,

3. Look for hints of the supervolatile O_2 observed at 67P. [3, 4, 5, 6]

The rapid motion of the comet during closest approach made tracking difficult, but just under one month after the encounter the comet was still near enough to explore the inner coma without exceeding HST's tracking rate for COS. Thirty-six total HST orbits were allocated for this observing program. In this talk we will present our initial results on these three categories, compare the results to observations from *Rosetta* Alice, and discuss the implications for remote observations of the inner comae of comets in the future. We will also address the study's impacts on future remote

observations of small bodies, specifically main belt comets.

3. Summary and Conclusions

HST COS observations of 46P/Wirtanen taken around the close approach allowed high spatial and spectral resolution spectra to be obtained. The low geocentric distance of the comet allowed characterization of the inner coma (<100 km) in the FUV for the first time since *Rosetta* Alice UVS observations and will be the last inner coma FUV spectra probing this region for at least the next 40 years in the absence of a new comet mission carrying a UVS. More explicitly, we will discuss the first results from these FUV observations and describe the physical processes, composition of the inner coma and compare them to Alice observations.

Acknowledgements

The research presented in this talk is supported by the Space Telescope Science Institute as part of HST program 15625. Part of this research was conducted at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with NASA.

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