EPSC Abstracts
Vol. 13, EPSC-DPS2019-761-1, 2019
EPSC-DPS Joint Meeting 2019

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

Characterizing the physical and chemical behaviour of comet 46P/Wirtanen

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1. Introduction

Comet nuclei are remnants from the planet formation era but cannot be observed directly from Earth. When they approach the Sun a cloud of gas dust obscures their nuclei, and their properties must be inferred from gas and dust surrounding them. Understanding the connection between the coma and nucleus is therefore critical. Comet 46P/Wirtanen passed Earth with an historic closest approach distance of 0.077 au (12 million km) on Dec. 16, 2018. Its apparition was widely anticipated by planetary scientists and was the target of a world-wide observing campaign. Studies of comet Wirtanen around the time of its close approach to Earth provided spatial resolutions high enough to permit valuable comparisons to the Rosetta observations of 67P/Churyumov-Gerasimenko and the Deep Impact/EPOXI fly-by results of 103P/Hartley 2. In this contribution, we will summarize the preliminary results from our global campaign that combined telescopes in and around Earth to characterize the physical and chemical behavior of comet 46P/Wirtanen.

2. Chandra and Hubble Space Telescope

Chandra X-ray observations were obtained on Dec. 3, 2018 and Dec. 13, 2018 to use the comet's X-ray emission to create a tomographic image of the bulk distribution of gas in the coma, and to compare the emission from solar wind charge exchange reactions between water molecules in the comet's atmosphere with reactions between H and He in the heliosphere. X-ray background subtraction is a common problem when observing extended sources, and we acquired long exposures of the part of the sky that the comet moved through. Despite this careful approach, only a marginal detection of 46P was made with ACIS-S likely owing to the detector's degradation, and analysis is on-going.

To connect the X-ray observations with the nucleus and the gas and dust surrounding it, parallel observations were scheduled with HST/WFC3. Tracking issues resulted in a loss of the observations acquired on Dec. 3, 2018, and to make up for these observations HST/WFC3 observed the comet again on Dec. 25, 2018.

3. Neil Gehrels Swift Observatory

Swift observed 46P four times between Nov. 28, 2018 and Jan. 12, 2019. The main goal of the observations was to acquire high cadence UVOT broad band imaging in the U, V, and UVW1 filters to measure variations in the gas and dust production (cf. [1]). Swift cannot track non-sidereal objects and significant trailing of the comet was avoided by using a large number of images with short exposures. In addition, part of the images was acquired in 'event mode', which allows time tagging of each incoming photon (at significant telemetry expense).

4. Las Cumbres Observatory

The robotic 0.4m and 1.0m telescopes of the global Las Cumbres Observatory were used between Sep. 9, 2018 and May 5, 2019 to monitor the long-term baseline of the activity of 46P and to use extended high-cadence monitoring to investigate the evolution of the comet's variability around its perihelion. Two filters (g' and r') were used to search for color

changes and as a proxy of the gas and dust content of the coma.

5. HST COS/STIS campaign

HST operations requires the use of guide stars when the sensitive COS NUV-FUV and STIS/MAMA detectors are used, but the apparent motion of the comet was too high during closest approach for this. HST spectroscopy observations were possible after Jan. 9, 2019 and were obtained between Jan 9, 2019 and Jan. 20, 2019. The observations aimed to use the unique close proximity of 46P to study the inner part of the coma (within 100 km of the nucleus), a region rarely accessible to remote observations. Using multiple FUV spectroscopy settings we will search for the emission of short-lived species (such as S_2, O_2), of molecules not accessible from the ground (CO_2), and we investigated the transitions between regions where either electrons or photons drive most of the chemistry in the coma. The results of the HST spectroscopy campaign are also discussed in another contribution [2].

Acknowledgements

We are grateful to observers around the world who reported their observations of 46P to the MPC, which allowed us to successfully observe the comet with HST. These include Nick Moskovitz, Marco Micheli, Bill Ryan, Dave Tholen, Paolo Bacci, Brian Skiff, Emmanuel Jehin, Chunua Qi, and Martin Cordiner. These observations were made possible by the efforts of the scheduling teams on CXO, HST, and Swift. We acknowledge support from Chandra GI grant 19100360; HST GO-15372 and GO-15625; Swift GI 1417065; and LCO observing time through NOAO programs 2018B-0221 and 2019A-0118.

References

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[2] Noonan, J. et al.: Hubble Space Telescope Cosmic Origins Spectrograph Observations of 46P/Wirtanen During Close Approach. AAS-DPS/EPSC, 2019.