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Photometry, imaging and rotation period of comet 46P/Wirtanen during its 2018 apparition

Youssef Moulane (1,2,3), Emmanuel Jehin (2), Francisco José Pozuelos (2), Cyrielle Opitom (1), Jean Manfroid (2), Bin Yang (1), and Zouhair Benkhaldoun (3)
(1) European Southern Observatory, Alonso de Cordova 3107, Vitacura, Santiago, Chile (ymoulane@eso.org),
(2) Space sciences, Technologies & Astrophysics Research (STAR) Institute, University of Liège, Belgium ,
(3) Oukaimeden Observatory, High Energy Physics and Astrophysics Laboratory, Cadi Ayyad University, Morocco.

Abstract

We report on photometry, imaging and the rotation period of the Jupiter Family Comet (JFC) 46P/Wirtanen (hereafter 46P) observed with both TRAPPIST telescopes (TN and TS [1]). We monitored the comet regularly during 8 months, following the evolution of the production rates of the gaseous species, e.g. OH, NH, CN, C_3 and C_2, as well as the evolution of the A(θ)fρ parameter, a dust proxy. Measurements along the orbit of the production rates and the relative abundance with respect to CN and OH will be discussed. We measured the rotation period of the comet using high cadence observations of the CN flux on several nights, we obtained a value of (9.2±0.5) hr on Dec. 9, 2018. The comparison of the coma morphology exhibited by the gas species and the dust will be presented.

1. Observation & Data Reduction

46P's return was long expected, as it did an unusually close approach to the Earth (0.0775 au) in December 2018, about only 30x the distance to the moon and with an excellent visibility from both hemispheres. This allowed to observe the comet in great detail with a large set of ground-based telescopes[1]. We collected TRAPPIST data for 46P over 8 months, from the beginning of August 2018 (r_h=1.88 au) to the end of March 2019 (r_h=1.70 au), with both TN and TS telescopes. 46P reached its perihelion on December 12, 2018 a distance of 1.06 au from the Sun and only at 0.08 au from the Earth.

Data calibration followed standard procedures using frequently updated master bias, flat and dark frames. The removal of the sky contamination and the flux calibration were performed. In order to derive the production rates, we converted the flux for different gas species (OH, NH, CN, C_3 and C_2), through the HB narrow band cometary filters [2], to column densities and we have adjusted their profiles with a Haser model [3]. The model adjustment is performed around a physical distance of 10000 km from the nucleus. We derived the water production rate from our OH production rates using $Q(H_2O)=1.36\ r^{-0.5}\ Q(OH)$ [4]. We derived the Afρ parameter, proxy of dust production [5], from the dust profiles using the HB cometary dust continuum BC, GC and RC filters and the broad-band Rc and Ic filters. We corrected the A(θ)fρ from the phase angle effect to obtain A(0)fρ.

2. Production rates

46P is a JFC with an orbital period of 5.5 years. It is a hyperactive comet, belonging to a small family of comets whose activity levels are higher than expected, based on the size of their nucleus. As this comet made an unusually close approach to the Earth, an international observing campaign was setup for this exceptional comet.

During 8 months of observation with TRAPPIST telescopes, the production rates were derived for OH, NH, CN, C_3, and C_2, along with a measure of the dust production proxy, A(θ)fρ parameter. The various gas species and the dust activity increase regularly with time approaching perihelion. The peak water production was reached at perihelion with $(7.20\pm0.24)\times10^{27}$ molecules/s, while the peak value of Afρ was (115±8) cm. After perihelion, both the gas and dust production rates dropped as the comet was moving away from the Sun. We lost the CN and C_2 detection on March 20, 2019 (r_h=1.62 au). New values for the relative abundances were computed, and a comparison to other comets indicates that 46P has a "typical" composition and a low dust-to-gas ratio. Our results for the 2018 passage are compared to previous apparitions [6, 7] which were collected as parts of surveys and support to the Rosetta mission, when 46P was its target.

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[1] http://wirtanen.astro.umd.edu/46P/index.shtml

3. CN Rotation period

For very active comets, inner coma photometry is one of the best methods to determine the rotation period of the nucleus with ground-based telescopes. Knowledge of the correct rotational state of a cometary nucleus is essential for the accurate interpretation of observations of the coma and for the determination of nuclear activity and its distribution on the surface. The spin state, orbital motion, and activity of a comet are linked to each other. As 46P was an hyperactive comet, we investigated on the rotation period using the flux variation method. Thanks to the equatorial position of the comet we could obtain very long photometric series by observing with TN from Morocco for several hours first then with TS from Chile for many more hours to obtain a continuous light curve of about 12 hours. We collected series of images continuously with the CN and C_2 filters on several nights before and after the perihelion. On December 9, 2018, we found a (9.2±0.5) hr. A month after the perihelion, on January 2, 2019, we found a rotation period of (8.6±0.6) hr, still in agreement with the first measurement. No obvious acceleration or braking was observed along the period of observation.

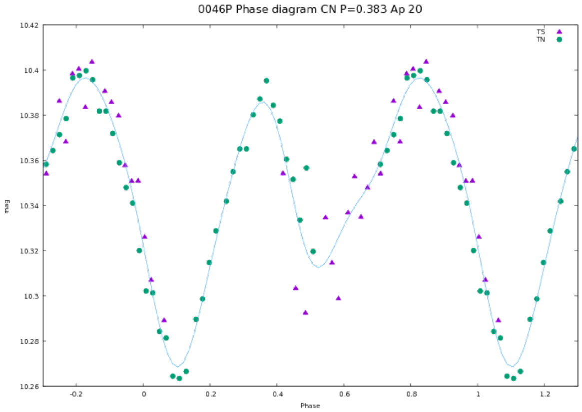

Figure 1: A phased rotation period of (9.2 ± 0.5) hr of 46P using CN flux variations of the inner coma during the night December 9, 2018 with TS and TN (Jehin et al 2019, CBET 4585).

4 Coma features

The study of the comet's morphology can give us information about the rotation period, active areas, and homogeneity of the nucleus.

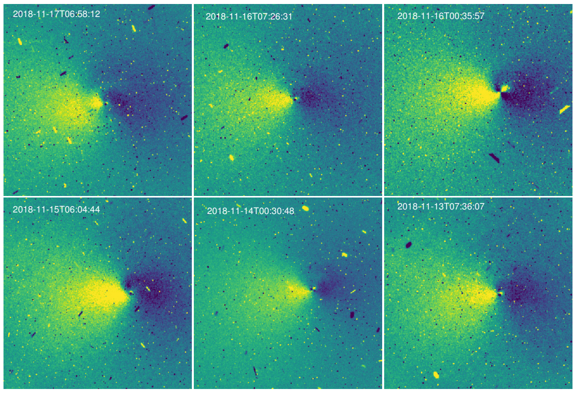

Figure 2: CN coma morphology during the nights November 13, 14, 15, 16 and 17, 2018 with TS.

In this work, we investigated on the morphological features of gaseous species and broadband continuum images, using a simple rotational filter technique. A comparison of these features with different filters and at several epochs will be presented.

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