Composition and activity of comet C/2020 M3 (ATLAS) with the TRAPPIST-North telescope

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Abstract

*TRAPPIST (for **TRA**nsiting **P**lanets and **P**lanetes**I**mals **S**mall **T**elescope) is a set of two twins robotic telescopes with a diameter of 60 cm. TRAPPIST-South was installed at La Silla ESO Observatory (Chile) in 2010 [1], and TRAPPIST-North at the Oukaimeden Observatory (Morocco) in 2016. The TRAPPIST telescopes are entirely robotic, equipped with a sensitive CCD camera and a complete set of narrow and broad-band filters. They allow to measure the production rates of several gas species (OH, NH, CN, C_3 and C_2) and the dust [2]. With these two telescopes, we follow-up comets activity continuously along their orbit from both Northern and Southern hemispheres. In this work, we present the results of comet C/2020 M3 (ATLAS). We show its chemical composition and activity evolution over a wide range of distances from the Sun and on both sides of perihelion. We measure the production rates of each daughter molecule using the Haser model [3], in addition to the $Af\rho$ parameter to estimate the dust production in the coma. We calculate the ratios of production rates with respect to OH and CN for different molecules as well as the gas/dust ratio. These results allow us to classify the comet C/2020 M3 (ATLAS) in the current taxonomy [4] and better understand the link between comets chemical compositions and their origin.*

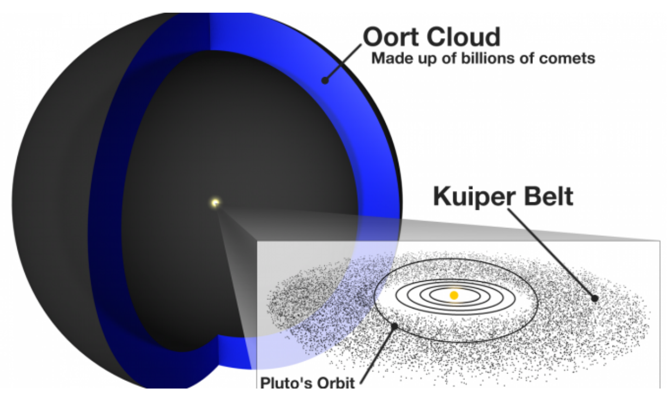
1. Comets

1.1 Definition

A comet is a small body of the Solar system with a diameter of about few kilometers to tens of kilometers, made of ice and dust. Its name comes from the Greek "coma" which means "tail". Indeed, when a comet approaches the Sun, a part of its matter sublimates and the body develops a tail of dust several milllions of kilometers long. This material reflects the light of the Sun, which makes the comet visible from the Earth.

1.2 Origins of comets

Our current knowledge about the origin of comets indicates that they come from two major reservoirs : the Oort cloud and the Kuiper belt. The first reservoir surrounding our solar system is the Oort cloud, named after the Dutch astronomer Jan Oort. It is a vast hypothetical spherical set of bodies located mainly between 20 000 and up to more than 100 000 astronomical units (au).



The Kuiper belt is the second reservoir of comets. It can be represented as an area of the solar system extending beyond the orbit of Neptune, between 30 and 55 au, it is mainly composed of small bodies, remains of the formation of the Solar System.

1.3 Comets activity

When a comet approaches the Sun, it begins to sublimate under the effect of solar radiation. The cloud of gas and dust that surrounds the comet nucleus, called **coma**, is formed by the sublimation of volatile molecules from the nucleus and dust particles embedded in the ice. The expelled matter is then redistributed in two main types of tails, which can extend over several million kilometers: a **dust tail**, and an **ion tail** oriented towards the anti-solar direction. Figure 2 shows an artistic view of different components of a typical comet.

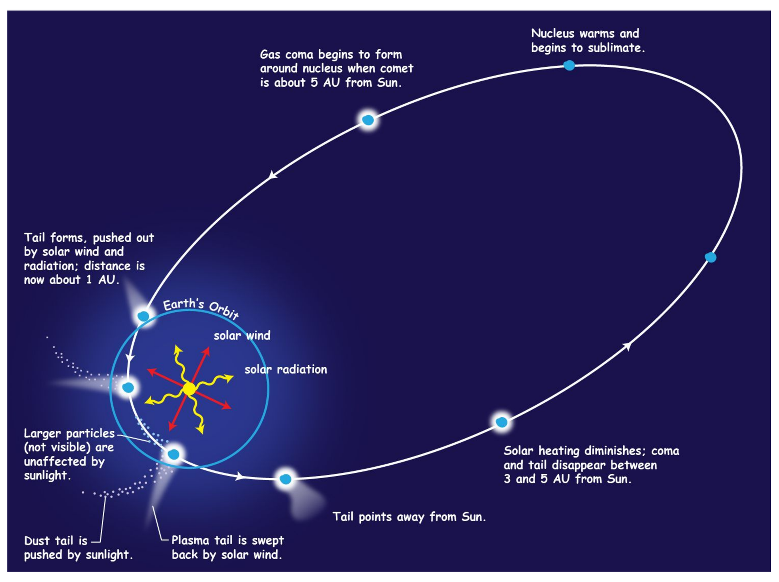


Figure 2: *Evolution of a comet activity (NASA)*

2. TRAPPIST

2.1 TRAPPIST: sites and instrumentation

The TRAPPIST telescopes are Ritchey-Chretien robotic telescope, funded by the University of Liège and FNRS (Belgium). Trappist-North was installed in 2016 at the Oukaimeden Observatory in Morocco. The Oukaimeden Observatory was founded by Cadi Ayyad University in 2007. It is located 80 km south of Marrakech in the High Atlas Mountains, at an altitude of 2750m. The observatory offers good observing conditions in a semi-desert area, with about 250 clear nights per year. TRAPPIST-South in 2010 at ESO Observatory in chile in Chile [7].

Figure 3: *TRAPPIST-North at Oukaimeden Observatory, Morocco (IAU code: Z53).*

Half of the TRAPPIST observation time is allocated to the study of comets, while the other part is used to observe exoplanet transits.

2.2 TRAPPIST and comets

With TRAPPIST, we study several aspects of comets. The first is to follow the evolution of the activity of bright comets (magnitude <12) week after week. The volatiles production rates are retrieved from OH, CN, NH, C_2 and C_3 HB narrow band cometary filters [2] images, while the dust production rates ($Af\rho$) are estimated from BC, RC, UC and GC continuum filter images. The estimated production rates and gas/dust ratio allow to classify chemically the comets. Images are also taken with Johnson-Cousin broadband filters B, V, Rc and Ic. The second aspect consists in studying the morphology of the coma to determine, for example, the rotation period of comets using different techniques [5].

3. Monitoring of comet C/2020 M3 (ATLAS) with TRAPPIST-North

3.1 C/2020 M3 (ATLAS)

Comet C/2020 M3 (ATLAS) was discovered on June 27, 2020, by the ATLAS monitoring network (Asteroid Terrestrial-Impact Last Alert System). This work is based on observations made with the TRAPPIST-North telescope. The raw images of the comet are not directly usable, they are impacted by instrumental and observational effects that needs to be corrected. Using scripts (IRAF, PYTHON) already developed by the team, we can reduce the data in large quantities [8]. An example of reduced images in different filters is shown in figure 4.

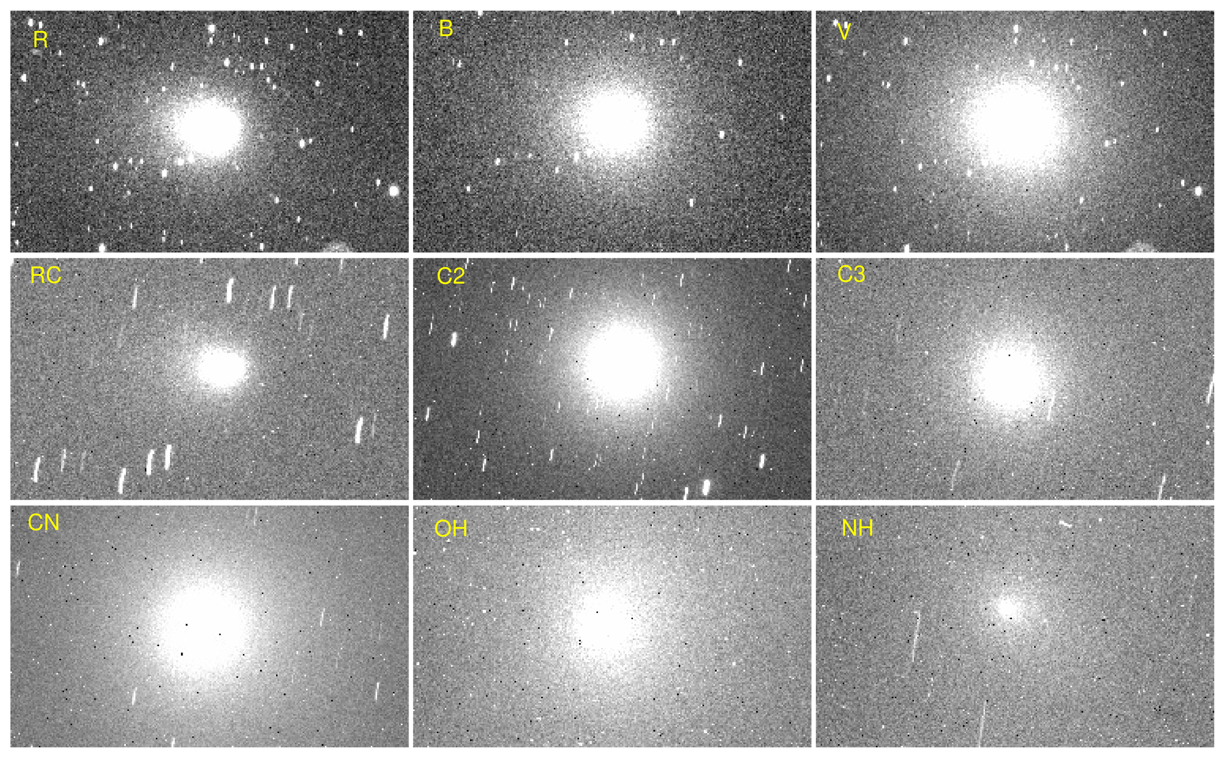


Figure 4: *Examples of reduced images of comet C/2020 M3 (ATLAS) taken with TN.*

3.2 Production rates and the $Af\rho$ parameter

Figures below show the evolution of the production rates and the $Af\rho$ parameter of comet C/2020 M3 as a function of heliocentric distance. Both graphs are shown in logarithmic scale. As we can see, the variation of all radicals has the shape of a downward-pointing parable. The comet activity rises as it approaches perihelion and then decreases after perihelion.

For the dust we notice an asymmetry of the light curve around perihelion, which could be explained by the fact that the dusts react and disperse more slowly in the coma than gaseous species (seasonal effect).

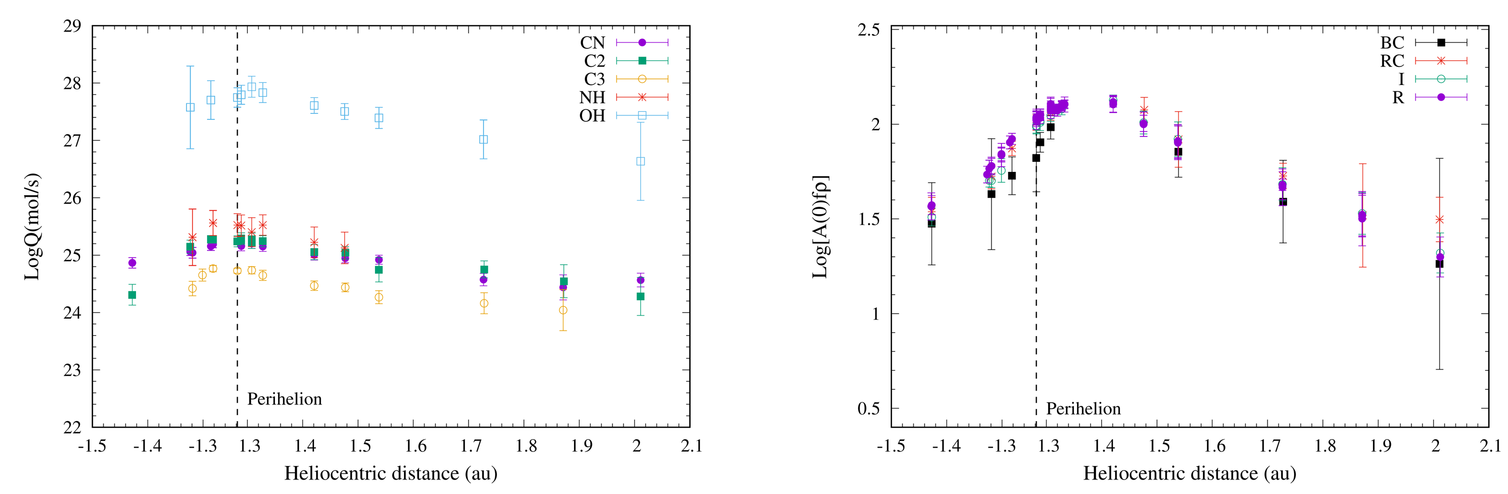


Figure 5: *The evolution of the production rates, and the $Af\rho$ parameter as a function of the heliocentric distance.*

3.3 Chemical classification

The ratios of different molecules with respect to OH and to CN have been calculated in order to determine the taxonomy class of comet C/2020 M3 (see Table below). Based on the classification given in A'Hearn et al. 1995 [6], our results show that comet C/2020 M3 has a typical composition and no depletion in carbon chain elements (C_2 and C_3).

Log Production rates ratios			
	C/2020 M3 (This work)	Typical comets A'Hearn et al. 1995	Depleted comets
C_2/CN	0.05 ± 0.01	0.06 ± 0.10	-0.61 ± 0.35
C_3/CN	-0.51 ± 0.02	-1.09 ± 0.11	-1.49 ± 0.14
C_N/OH	-2.55 ± 0.02	-2.50 ± 0.18	-2.69 ± 0.14
C_2/OH	-2.58 ± 0.02	-2.44 ± 0.20	-3.30 ± 0.35
C_3/OH	-3.18 ± 0.02	-3.59 ± 0.29	-4.18 ± 0.28
NH/OH	-2.32 ± 0.03	-2.37 ± 0.27	-2.48 ± 0.34
$Af\rho/CN$	-23.33 ± 0.01	-23.30 ± 0.32	-22.61 ± 0.15
$Af\rho/OH$	-26.03 ± 0.03	-25.82 ± 0.40	-25.30 ± 0.29

References

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