Early results for 41P/Tuttle-Giacobini-Kresak during its last incursion in the inner Solar System based on TRAPPIST telescope network observations

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The importance of comets

According with the current theories, comets are the most volatile and least processed materials in our Solar System, which was formed from the primitive nebula 4.6 Gyr ago. They are considered as time capsules and building blocks of the planets, and might have an important role in the early Earth hydration process [1]. Also, they are the most organic-rich bodies in the Solar System providing ready-formed molecules possibly involved in the origin of life on Earth. In addition, impacts to the planets at hyper-velocities cause major changes in climate and, in the case of Earth, dramatically affecting the ecological balance, possibly including the extinction of the dinosaurs. In concrete, it is well know the importance of short period comets, which are also called Jupiter Family Comets, because they offer the possibility to be studied during several passages near perihelion when the activity increases. An example of this family is the famous 67P/Churyumov-Gerasimenko, which is the best comet studied ever because the Rosetta mission [2] and the large ground based observation campaign in support of it [3]. To this cometary family also belong the comet 41P/Tuttle-Giacobini-Kresak, specially interesting since it is one of the three close-to-Earth comets observables during 2017 and 2018.

Rosetta mission legacy

As the first spacecraft to orbit a comet, drop a lander – Philae – on to its surface and travel alongside it as it swung around the Sun, Rosetta has probably captured the public imagination like no other ESA mission before. Important scientific results were obtained as the fact that the water vapor is substantially different from the found on Earth, what makes it very unlikely that water found on Earth came from comets. In concrete, it was obtained a detailed characterization of the dust grains, where several parameters such as albedo, density, size distribution etc, have been measured as never before. These results are specially interesting for us and we incorporate them into our dust models.

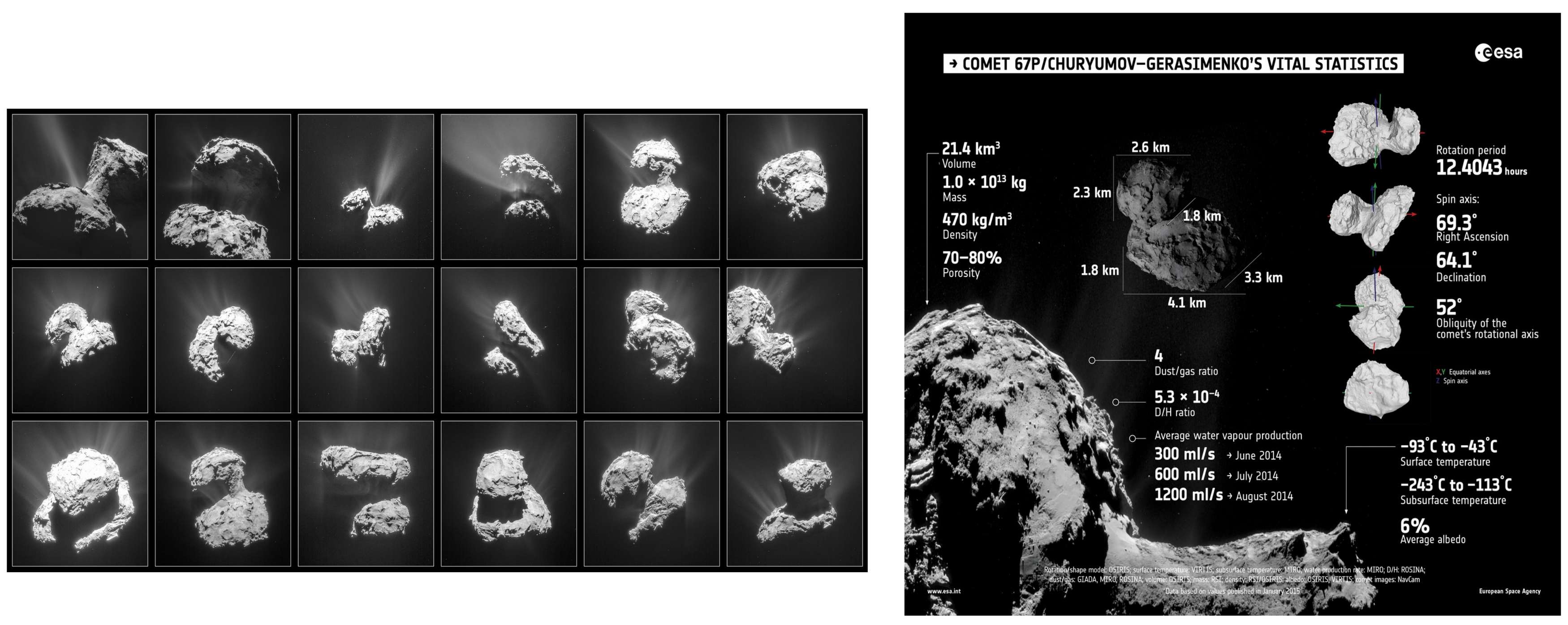

Fig 1. ESA images about the comet 67P/Churyumov-Gerasimenko after Rosetta mission.

TRAPPIST telescope Network

TRAPPIST (TRAnsiting Planets and PlanetesImals Small Telescopes) telescope network is a set of two 60-cm robotic telescopes installed at the ESO La Silla Observatory in Chile [4] , TRAPPIST-South, and at Oukaimeden observatory in Morocco, TRAPPIST-North. With this configuration both Northern hemisphere and Southern hemisphere are accessible during the whole year. The large amount of observing time available allows us to follow the evolution of the activity of bright comets (Vmag<12) for several months around their orbits. To learn more about the TRAPPIST telescopes visit the poster entitled: *Monitoring of comets activity and composition with the TRAPPIST-North Telescope*

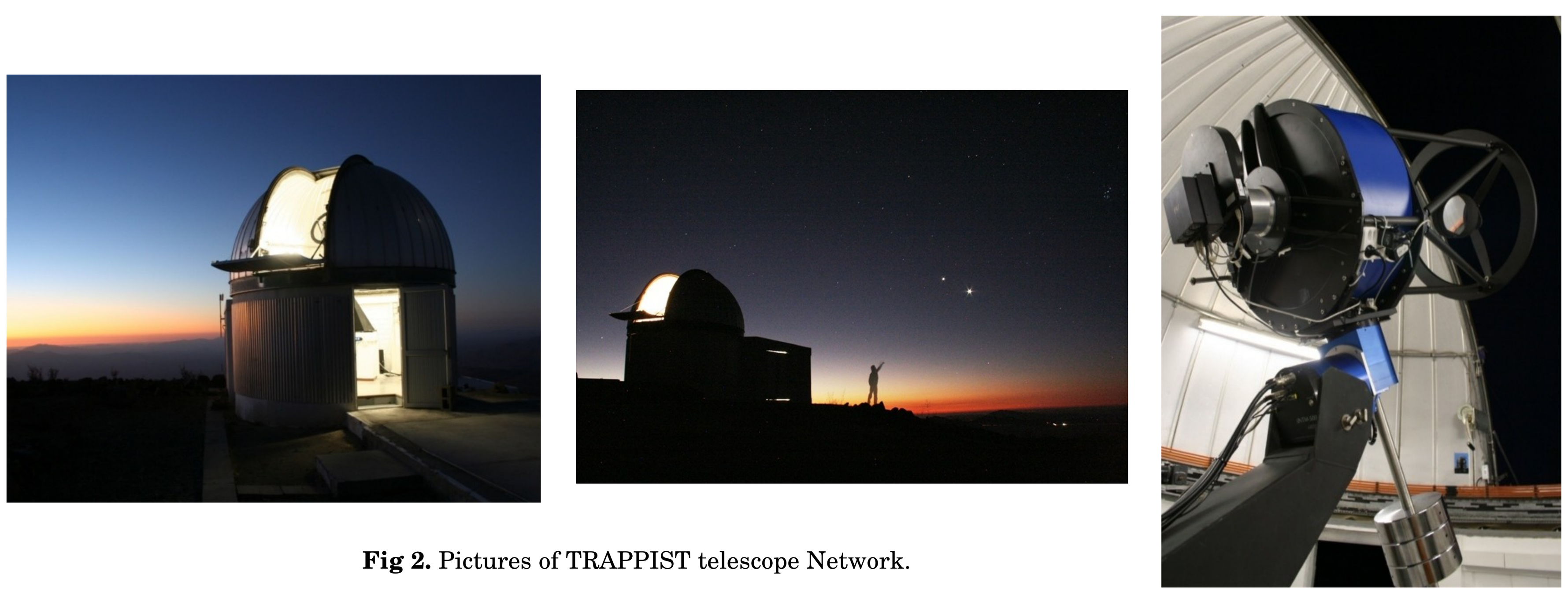

Fig 2. Pictures of TRAPPIST telescope Network.

The comet 41P/Tuttle-Giacobini-Kresak

We collected more than 30 observations nights, ranging from -1.5 AU to +1.7 AU. We characterized the activity using a Monte Carlo dust tail code [5]. From this analysis, we derive the dust parameters, which best describe the dust environment: dust loss rate, ejection velocities, and size distribution of particles. On the other hand, we performed an dynamical analysis using the N-body integrator REBOUND [6], which allow us to determine the stability degree of this comet on its current orbit as well as the time spent in the region of the Jupiter Family Comets and future steps in its evolution in the Solar System.

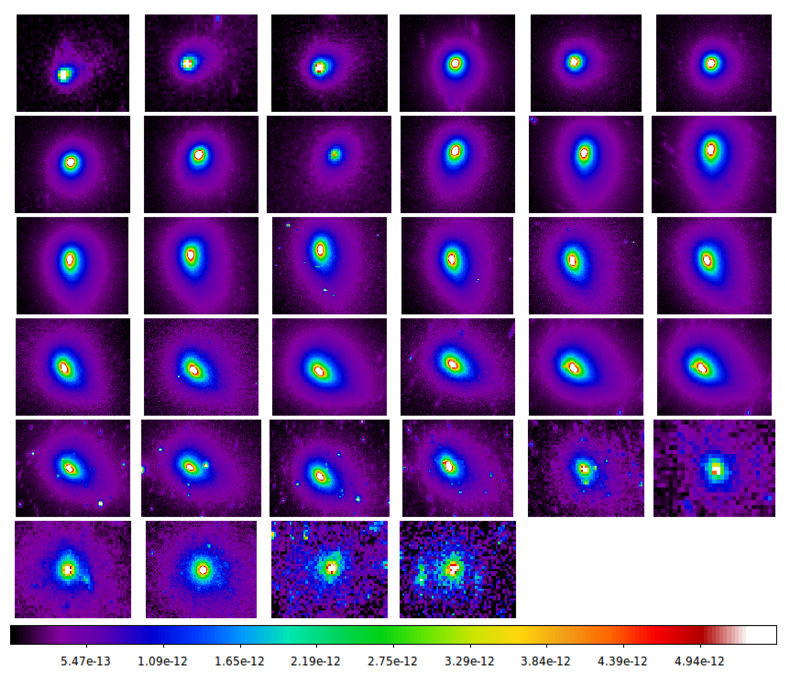

Fig 3. Complete set of observations of 41P during its last perihelion approach.

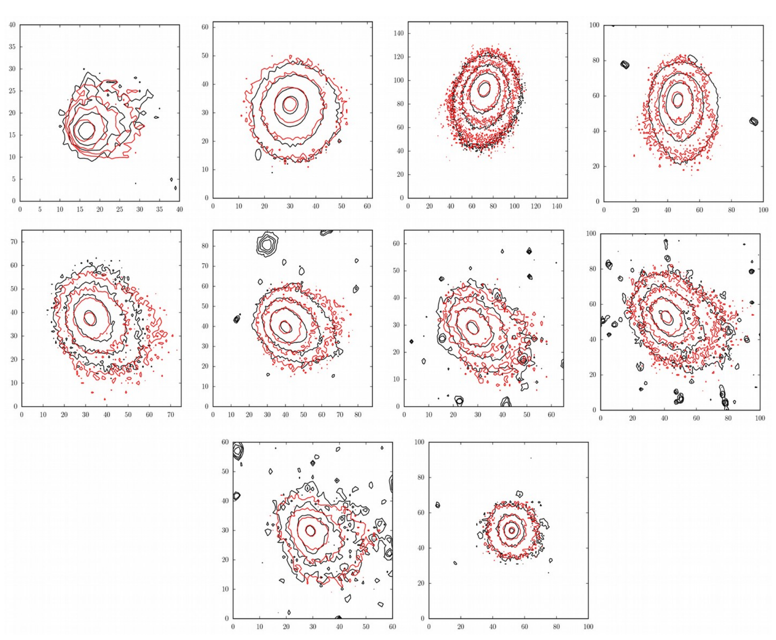

Fig 4. Comparison of the dust model with the observation. The model being red contours and the observations black.

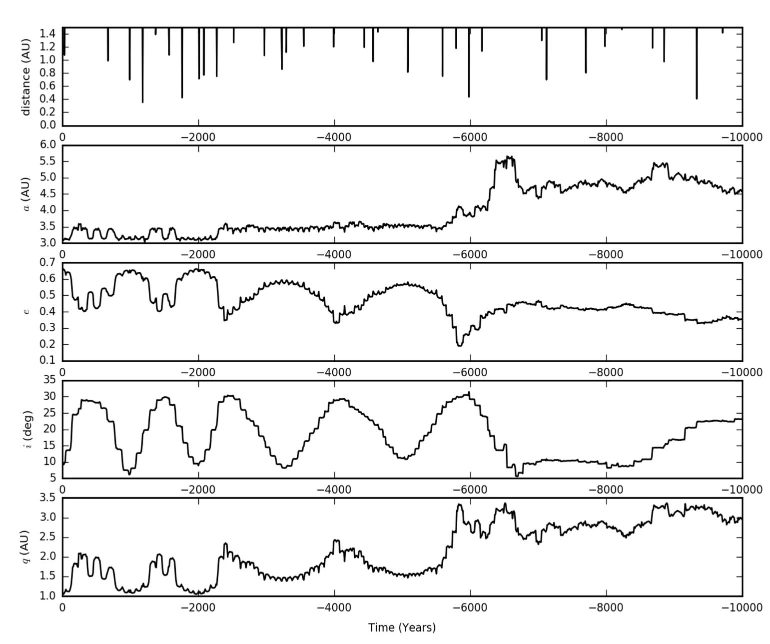

Fig 5. Orbital parameter evolution of 41P from current time to -10000 yrs. Close encounters (top panel) with Jupiter provoked important changes in the orbit.

From our dust characterization we found that this comet is not very dusty. The total of dust emitted being 7.5 x 10^8 kg during its last incursion, the peak of the emission being 110 kg/s. That means a contribution of 0.07% to the annual interplanetary dust replacement. The ejection velocities of particles are in the range of 100 m/s for the smallest particles (10 micron) and 1 m/s for the largest (30 cm). In addition, we found that the emission pattern is complex. In principle, the ejection was isotropic but become anisotropic soon, the active areas being in the north and the south hemispheres. From our dynamical study we obtain that this comet suffered several close encounters with Jupiter which provoked important changes in its orbit. We also performed a statistical study where we obtained the time that this object will be in the Jupiter family region with different confidence levels (CL): 5500 yrs (100% of CL), 21700 yrs (90% of CL), 44700 yrs (80% of CL) and 60500 yrs (70% of CL). Its current age being, at least, 2100 yrs.

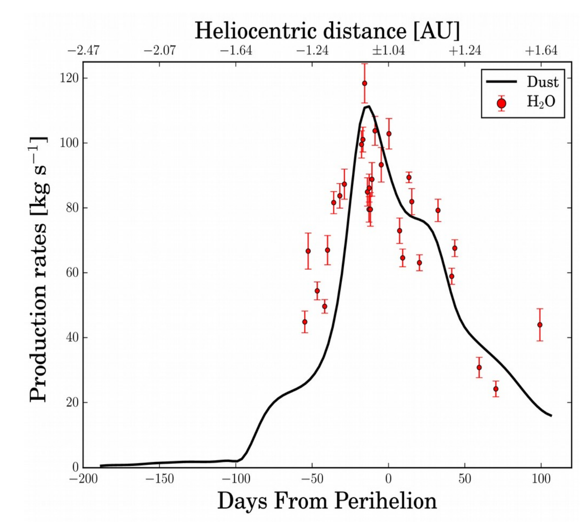

Fig 6. Dust production rate compared with water production rate as a function of the heliocentric distance and time to perihelion. The water production rate was obtained through the observations in OH filter.

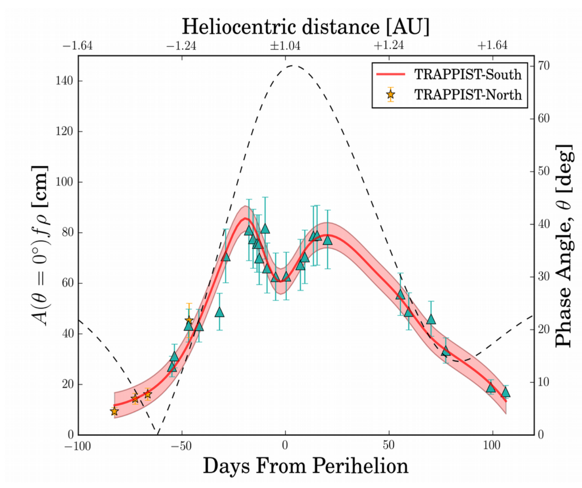

Fig 7. Comparison of the Afrho evolution between the observations and model. The dashed line reefers to the phase angle. The Afrho parameter is given for phase angle of 0 deg.

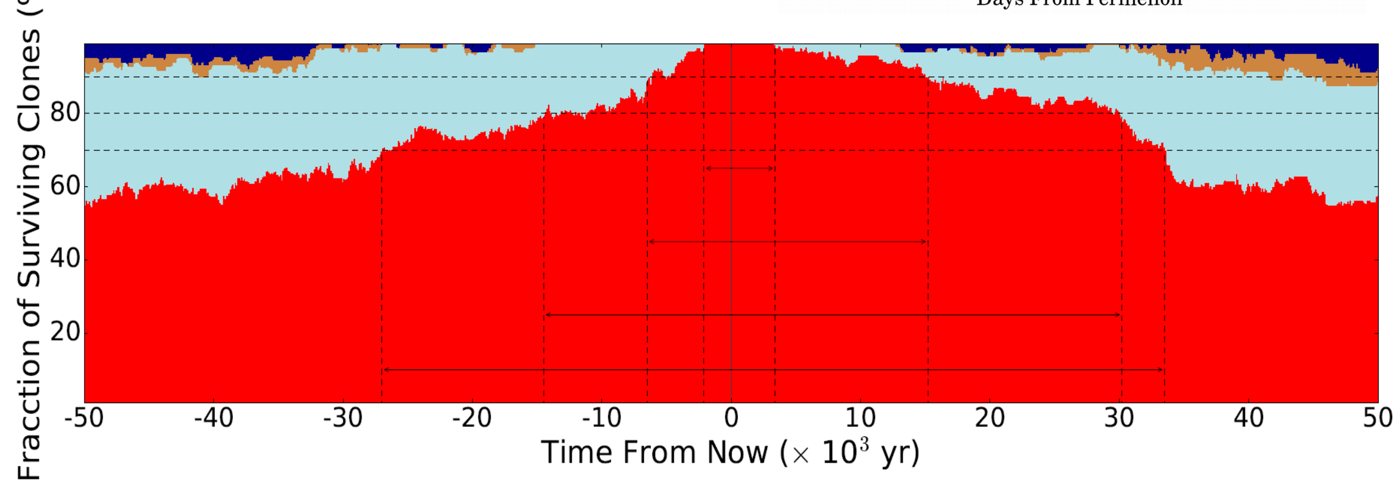

Fig 8. Statistical study of the regions in the Solar System most visited by 41P. Red: Jupiter Family comet. Clear blue: Centaurs. Yellow: Halley type comet. Dark blue: Transneptunians.

References

[1] Hartogh, P. et al. Nature 478, 218-220 (2011)

[2] Fornasier, S. et al. Science 354, 1566-1577 (2016)

[3] Snodgrass, C. et al. RSPTA 375, 2097 (2017)

[4] Jehin, E. et al. Msngr 145, 2-6 (2011)

[5] Moreno, F. et al. ApJ 752, 136-148 (2012)

[6] Rein, H. et al. A&A 537, 128-138 (2012)

Acknowledgments

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