EPSC Abstracts
Vol. 12, EPSC2018-104-1, 2018
European Planetary Science Congress 2018

On the dust properties and dynamical evolution of the near-Earth Jupiter family comet 41P/Tuttle-Giacobini-Kresak

F.J. Pozuelos (1), E. Jehin (1) , Y. Moulane (1,2), C. Opitom (3), J. Manfroid, Z. Benkhaldoun (2), and M. Gillon (1)
(1) Space sciences, Technologies and Astrophysics Research (STAR) Institute, Université de Liège, 19C Allée du 6 Août, B-4000 Liège, Belgium (fjpozuelos@uliege.be). (2) Oukaimeden Observatory, High Energy Physics and Astrophysics Laboratory, Cadi Ayyad University, Marrakech, Morocco. (3) European Southern Observatory, Alonso de Cordova 3107, Vitacura, Santiago, Chile.

Abstract

We present a study of the evolution of the dust environment of the near-Earth Jupiter family comet (hereafter NEJFC) 41P/Tuttle-Giacobini-Kresak, based on observational data obtained using TRAPPIST telescopes from January to July, 2017. In addition, we performed numerical simulations to constrain its origin and dynamical nature. These results have been recently accepted for publication in [1].

1. Introduction

Thanks to the Rosetta mission, our understanding of comets has greatly improved. A very good opportunity to apply this knowledge appeared in early 2017 with the near-Earth Jupiter family comet 41P, which during its perihelion passage was only 0.15 au from the Earth. It was then that it attracted international attention and many observatories started to monitor its behaviour. We performed long-term monitoring of 41P using the TRAPPIST telescopes [2]. For our dust modelling purposes, we used the broad-band R Johnson-Cousin filter. The observational campaign lasted from January 20 to July 27, 2017. During that period we obtained 30 photometric nights of observations that were used in our analysis.

2. Results

2.1 Dust model

To model the observational data set we used a Monte Carlo dust tail model [3], which allowed us to derive the time-evolution of the dust parameters: dust production rate, the size distribution and ejection velocities of the dust particles, and its emission pattern. Our main result was that it is not possible to explain the complete set of observations using a full isotropic ejection model. In fact, we found that a complex ejection pattern which switched from full isotropic to anisotropic (February 24-March 14), and then back from anisotropic to full isotropic again on June 7-28 provides the best description of the observations (Fig 1), we called this model *hybrid model*. During the anisotropic period, we found that $\sim$ 90% of the ejected particles came from two strongly active areas, one located in the northern hemisphere and the other in the southern. This model is in agreement with the recent discovery of the fast rotational period variation reported by [4] from March to May, 2017, in the sense that the two powerful active areas could have acted as brakes, increasing the nucleus rotation period. In general terms, from the dust model we obtained that the total dust mass ejected is $\sim 7.5 \times 10^8$ kg. This quantity is roughly the total dust ejected by the comet during the whole orbit. This amount of dust is low compared to other comets of the same family; however, 41P is a small comet, and this quantity represents a non-negligible fraction of its total mass. This implies that 41P suffered a substantial amount of erosion during its last incursion to perihelion. From observations of gases also performed with TRAPPIST telescopes we found that the dust-to-water mass ratio was low ranging from 0.25 to 1.5.

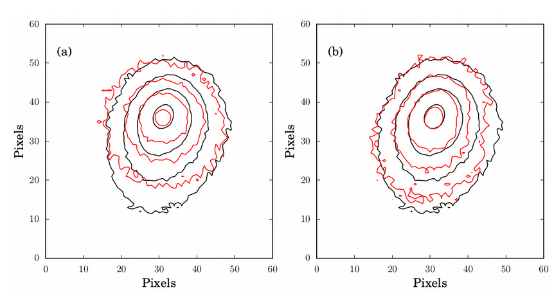

Figure 1: Comparison between full isotropic model (a), and hybrid model (b).

2.2 Dynamical analysis

The main reason for studying the dynamical evolution of comet 41P is to understand how long this comet has been suffering its current rate of erosion, and for how long it will continue. Comet 41P is a NEJFC, that is, a JFC with a perihelion distance of q < 1.3 au. The recent work by [5] revealed a subgroup among NEJFCs that reside in highly stable orbits, with a likely origin in the main asteroid belt. This new class of objects could be the counterparts to the Main Belt Comets, that is, they may be asteroids disguised as comets. In order to clarify the dynamical nature of 41P, we performed numerical integrations following the same steps given by [5], where a likely dynamical path is defined as the average of the set of results obtained for a given object and its clones, characterised by the f_q index, f_a index, the capture time, t_{cap} ,and the closest approach to Jupiter, d_{min}. To perform this analysis we made use of the numerical package MERCURY6, where the Sun and the eight planets were included in the simulation. We obtained that $f_q \sim 0.02$, $f_a \sim 0.005$, $t_{cap} \sim 10^4$ yr and $d_{min} \sim 0.20$ au. This indicates that 41P is more stable in its orbit than typical a JFC, and it belongs to the Moderately Asteroidal category defined in [5]. With two extra experiments we obtained that 3600 yr is the period of time during which 41P will belong to NEJFCs (Fig 2.).

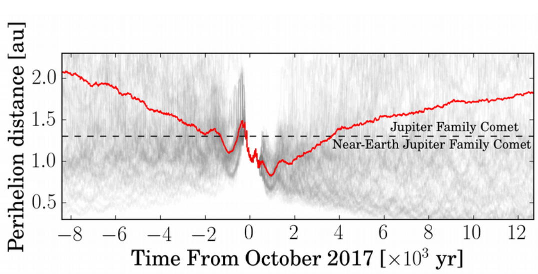

Figure 2: Evolution of the perihelion distance of 41P.

3. Summary and Conclusions

From our dust analysis we found that 41P is a dust-poor comet compared with other JFCs, with a complex ejection pattern which switched from full isotropic to anisotropic sometime during February 24-March 14 in 2017, and then back from anisotropic to full isotropic again between June 7-28. During the anisotropic period, the emission was controlled by two strong active areas, where one was located in the southern hemisphere and the other in the northern hemisphere of the nucleus. The total dust mass loss is estimated to be roughly 7.5×10^8 kg. From the dynamical simulations we estimated that about 3600 yr is the period of time during which 41P will remain in a similar orbit. Taking into account the estimated mass loss per orbit, after 3600 yr, the nucleus may lose about 30% of its mass. However, based on its dust-to-water mass ratio and its propensity to outbursts, the lifetime of this comet could be much shorter.

Acknowledgements

This work is supported by a Marie Curie CO-FUND fellowship, co-founded by the University of Liège and the European Union. TRAPPIST-South is funded by the Belgian Fund for Scientific Research (Fond National de la Recherche Scientifique, FNRS) under the grant FRFC 2.5.594.09.F, with the participation of the Swiss FNS. TRAPPIST-North is a project funded by the University of Liège, and performed in collaboration with Cadi Ayyad University of Marrakesh.

References

[1] Pozuelos, F. J., Jehin, E., Moulane, Y., et al. .: Dust modelling and a dynamical study of comet 41P/Tuttle-Giacobini-Kresak during its 2017 perihelion passage. A&A, in press (2018). preprint: arXiv:1805.00493

[2] Jehin, E., Gillon, M., Queloz, D., et al.: TRAPPIST: TRAnsiting Planets and PlanetesImals Small Telescope. The Messenger, 145, 2, 2011.

[3] Moreno, F., Pozuelos F. J., Aceituno, F., et al.: Comet 22P/Kopff: Dust Environment and Grain Ejection Anisotropy from Visible and Infrared Observations. ApJ, 752, 136, 2012.

[4] Bodewits, D., Farnham T., Kelley, M. S., et al.: A rapid decrease in the rotation rate of comet 41P/Tuttle-Giacobini-Kresak. Nature, 553, 186, 2018.

[5] Fernandez, J.A. & Sosa, A.: Jupiter family comets in near-Earth orbits: Are some of them interlopers from the asteroid belt?. Planet. Space Sci., 118, 14, 2015.