Revista Mexicana de Astronomía y Astrofísica Serie de Conferencias, 60, 77-78, (2026)
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OPEN ACCESS https://doi.org/10.22201/ia.14052059p.2026.60.73

"XVII LARIM", Montevideo, Uruguay, November 27 - December 1, 2023.Volume Editors: Gonzalo Tancredi, Cecilia Mateu & Juan José Downes

Physical properties, source regions, and total mass flux of decimetre-sized aggregates around 67P/Churyumov-Gerasimenko

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Keywords: *comets: individual: 67P, methods: data analysis, methods: numerical*

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This study focuses on analyzing large solid aggregates (∼ 10 cm) around comet 67P/Churyumov-Gerasimenko using data provided by the Rosetta mission. While the smaller particles were analyzed directly with the various on-board dust detectors, the larger particles were observed remotely only, so the information collected is sparse. To address this issue, a novel method is proposed. This method involves statistical comparison of the traces generated by the motion of the aggregates observed in OSIRIS images with those found in synthetic images, generated by modeling the trajectories of the aggregates. This made it possible to extract physical parameters of the aggregates, as well as information on their ejection mechanisms.

The first part of this work consists on the semi-automatic detection of tracks on images obtained by OSIRIS, the main imaging system onboard Rosetta, as described in Lemos et al. (2023). The images were acquired in five different sets between July 2015 (r_h = 1.32 au inbound) and February 2016 (r_h = 2.39 au outbound), totalling 189 images.

For each one of these real images, their synthetic counterparts were generated. These synthetic images are created by simulating the trajectory of the aggregates under the influence of comet and solar gravity, radiation pressure and gas drag. The gas flow description is the one presented by Marschall et al. (2020). The simulated trajectories depend on three aggregate properties, density ρ, radius r and initial velocity v_{in}, as well as the initial position on the comet surface.

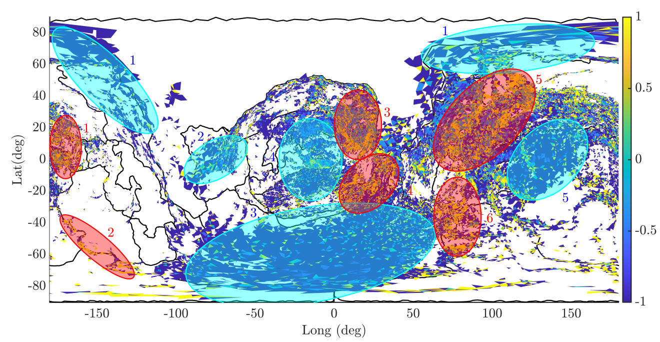

Figure 1. Map of the ejection efficiency regions on the surface of 67P. The high and low ejection efficiency clusters are shown with red and blue ellipses respectively.

Due to the movement of aggregates in front of the camera, they appear on the images as bright tracks instead of point sources. The last part consists on the comparison of the brightness, length and orientation of the observed tracks with the same properties of the synthetic ones. By selecting the aggregates that generate track properties distributions resembling the observed ones, we are capable of determining the aggregate properties and their spatial distribution on the surface.

We find that the aggregate properties are consistent among different epochs, with mean values $\rho \simeq 500$ kg m^{-3}, $r \simeq 10$ cm and $v_{in} \simeq 1$ m s^{-1}, similar to those reported in similar works (Pfeifer et al., 2024). Additionally, we were able to define the *ejection efficiency* as the probability of an aggregate coming from a certain position to generate a resembling track. The spatial distribution of ejection efficiency (Figure 1) is grouped in clusters of high and low ejection, related to heterogeneous and homogeneous terrain types respectively. This result is similar to the one presented by Vincent et al. (2016).

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