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Dust distribution and dynamics in the coma of 67P/Churyumov-Gerasimenko

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In this work, the motion of dust particles in the coma of the comet 67P/Churyumov-Gerasimenko is investigated. This is done by analyzing sets of images taken by OSIRIS, the main imaging system on board Rosetta, in which these dust particles can be seen as bright tracks instead of points sources, as result of the combination of motions of both particles and spacecraft. A fundamental obstacle to deriving the dust size and velocity distribution from such data is that without additional information, the apparent brightness of a particle constrains only the ratio of size and distance, but neither quantity individually.

While previous works in this area focused on obtaining the distance to individual detected particles in the image, a novel approach to analyze the dynamics of the dust is introduced in this work. This new approach is based on the statistical comparison between the images obtained by the camera, and synthetic images created by modeling the dynamics of the dust in the coma. The main advantage of this approach is to bypass the mentioned distance determination to the particles, which lifts the strict requirement on the observation conditions that were imposed by the earlier methods. This allows us to analyze a much larger set of images, and then, characterize the dust distribution and dynamics at the coma in a variety of conditions.

Our method can be divided in three main parts. First, dust tracks on the OSIRIS images are detected using an algorithm based on the Hough transform method. Secondly, the trajectories of dust particles under the influence of gas drag, nucleus gravity, and solar radiation pressure are modeled. These trajectories vary depending on the dust properties, such as density and size. The combination of the trajectories and the information about spacecraft position and orientation allows us to generate synthetic images for each type of modeled dust. Lastly, the distribution of selected track properties, like orientation, length and total brightness, obtained from the real images, is fitted by combining the ones obtained from the synthetic images. This allows us to estimate the contents of each type of dust in the coma.