EPSC Abstracts
Vol. 10, EPSC2015-473, 2015
European Planetary Science Congress 2015

Modelling of the sublimation of icy grains in the coma of comet 67P/Churyumov-Gerasimenko

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Abstract

The ESA (European Space Agency) Rosetta spacecraft was launched on 2 March 2004, to reach comet 67P/Churyumov-Gerasimenko in August 2014. Since March 2014, images of the nucleus and the coma (gas and dust) of the comet have been acquired by the OSIRIS (Optical, Spectroscopic, and Infrared Remote Imaging System) camera system [1] using both, the wide angle camera (WAC) and the narrow angle camera (NAC). The orbiter will be maintained in the vicinity of the comet until perihelion (R_h=1.3 AU) or even until R_h=1.8 AU post-perihelion (December 2015). Nineteen months of uninterrupted, close-up observations of the gas and dust coma will be obtained and will help to characterize the evolution of comet gas and dust activity during its approach to the Sun. Indeed, for the first time, we will follow the development of a comet's coma from a close distance. Also the study of the dust-gas interaction in the coma will highlight the sublimation of icy grains. Even if the sublimation of icy grains is known, it is not yet integrated in a complete dust-gas model.

We are using the Direct Simulation Monte Carlo (DSMC) method to study the gas flow close to the nucleus. The code called PI-DSMC (www.pi-dsmc.com) can simulate millions of molecules for multiple species.When the gas flow is simulated, we inject the dust particle with a zero velocity and we take into account the 3 forces acting on the grains in a cometary environment (drag force, gravity and radiative pressure).

We used the DLL (Dynamic Link Library) model to integrate the sublimation of icy grains in the gas flow and allow studying the effect of the additional gas on the dust particle trajectories. For a quantitative analysis of the sublimation of icy, outflowing grains we will consider an ensemble of grains of various radii with different compositions [2] The evolution of the grains, once they are ejected into the coma, depends on their initial size, their composition and the heliocentric distance (because the temperature of the grain is higher close to the Sun). The grain temperatures will be derived by assuming equilibrium between the energy absorbed from the Sun, the energy re-radiated in the infrared, and the cooling by sublimation. We will use Mie theory [3, 4] to compute the scattering properties of an assumed grain (grain size, shape and composition, including mineralogy and porosity). We follow the evolution of grains until the icy layer sublimates completely. Once ejected in the gas flow, the generated molecules have no preferred direction. First results highlighted that the sublimation has a significant influence on the dust trajectories and generates a gas cloud that moves with the velocity of the icy grains.

Our model can produce artificial images for a wide range of parameters, including outgassing rate, surface temperature, dust properties and sublimation of icy grains. The results of this model will be compared to the images obtained with OSIRIS camera and to the published data from other instruments.

References

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