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Modelling the inner coma of comet 67P/Churyumov-Gerasimenko

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Abstract

Based on about 1 million of pressure measurements around comet 67P/Churyumov-Gerasimenko we reconstruct the gas emission across the entire nucleus. Dust particles are seeded in the gas model and the resulting dust distribution follows a daily pattern which agrees with observations if a uniform dust release across the entire sunlit surface is assumed.

1. Introduction

The long-term evolution of the cometary coma from in-situ measurements by ROSINA on-board of the Rosetta spacecraft provided a unique opportunity to retrieve the gas and dust emission from an active cometary nucleus. We have taken a collisionless gas model, which incorporates the detailed bi-lobed shape of the nucleus and serves as the starting point for a simulation of the dust emission from the surface.

2. Distribution of gas sources on the surface

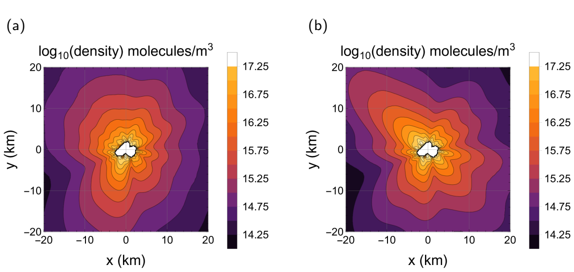

Figure 1: Gas number density N_{gas} for water around comet 67P/C-G (slice at $z = 0$) for (a) a best fit coma model for April 2015 to the COPS data set [1] and for (b) homogeneous gas emission.

The reconstruction of the three-dimensional gas density around the nucleus is done by fitting the Comet Pressure Sensor (COPS) data to uniformly distributed surface sources [1]. The resulting gas coma is shown in Fig. 1, before the fit (b) and with adjusted emission rates (a) [3]. The fit reduces the gas emission above the big lobe, but the homogeneous case already shows the influence of the concave neck area on the gas distribution. In addition to more broadly distributed sources, some gas emission areas are concentrated on the southern hemisphere. These areas are correlated with short-lived gas outbursts occurring around perihelion [5]. Already several months before the eventual outburst, the localized emitters release CO2 and their elevated activity lasts until the end of the Rosetta mission [4].

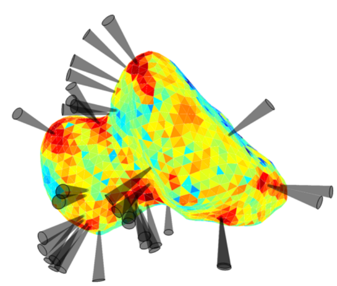

Figure 2: Reconstruction of localized gas sources (highest emission rate colored red) on the surface of 67P/C-G [1, 4] and locations of observed dust outbreaks [5].

3. Dust release from the surface

Two distinct dust release processes are observed by Rosetta. Short lived, eruptive outbursts and dust "jets" observed at any instance in the inner coma. The latter inner coma structures are highly dependent on the perspective and relative position of observer (Rosettas cameras) with respect to the nucleus. They are faith-

fully reproduces by assuming a uniform seeding of the gas emitters with dust particles [2, 3].
The observed bending of the dust coma provides an independent measurement of the dust velocity based on the Coriolis effect. We find that the dust particles are quickly accelerated close to the surface and at distances of a few kilometers reach velocities around 3 m/s [3].

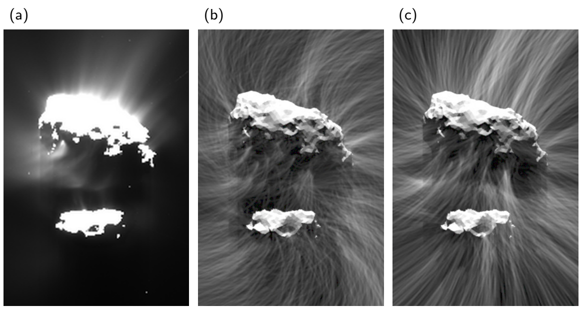

Figure 3: Parametric study of varying dust-gas interactions (α = 0.5-1,8) for the Rosetta viewpoint on 2015-04-24 09:30 UTC (see [3] for more details). (a) contrast enhanced WAC image (id: W20150424T092929750ID30F13, filters: empty+UV375, exposure: 36.45 s, direction to Sun upwards) to emphasize the dust in the shadowed neck area. Best agreement of the OSIRIS image with the simulation is obtained for small $\alpha = 0.5$-1 in the shadowed area (b), while outside the nucleus dust from sunlit areas fits better with higher $\alpha = 8$ (c). The parameter $\alpha = 3/(4\rho_{\rm dust} R_{\rm dust})$ is related to the dust particle radius $R_{\rm dust}$ and density $\rho_{\rm dust}$.

4. Summary and Conclusions

The gas emission of 67P/C-G has been determined from in-situ gas pressure measurements and reveals the gas sources across the entire nucleus, with CO2 at all times predominantly released in the southern hemisphere [4]. The observed dust and jet-like structures near the nucleus are determined by the perspective of the observer with respect to the nucleus. Concave surface areas lead to a focusing of dust densities, causing a ray-like structure emerging from the surface for certain alignments [2]. The Coriolis has been used to constrain the dust velocity.

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