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Linking cometary coma data to the surface emission distributions: Limitations of models and ways out - a Rosetta perspective on data collected on comet 67P.

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Abstract

Numerical models are powerful tools for understanding the connection between the emitted gas and dust from the surface of comets and the subsequent expansion into space where remote sensing instruments can perform measurements. We have applied a state of the art 3D DSMC gas dynamics code to simulate the inner gas coma of different models that vary in the fraction of the surface that contains ice and in different sizes of active patches. These different distributions result in jet interactions that differ in their dynamical behaviour. We will present synthetic measurements of Rosetta's gas instruments. By comparing the different models we probe the limitations of the different instruments to variations in the emission distribution and how to overcome these limitations.

1 Introduction

The European Space Agency's (ESA) Rosetta mission has returned a vast data set of measurements of the inner gas coma of comet 67/Churyumov–Gerasimenko. These measurements have been used by different groups [1, 2, 3, 4, 5] to determine the distribution of the gas sources at the nucleus surface. The solutions that have been found differ from each other substantially and illustrate the degeneracy of this issue. We explore the origin of this degeneracy and how it can be lifted. It is the aim to this work to explore the limitations that current gas models have in linking the coma measurements to the surface. In particular we discuss the sensitivity of Rosetta's ROSINA, VIRTIS, and MIRO instruments to differentiate between vastly different distribution of the gas emission.

2 Results

We have applied a state of the art 3D DSMC gas dynamics code to simulate the inner gas coma. The different models we have examined vary in the fraction of the surface that contains ice. The activity is further constrained to different sizes of active patches (diameters of $\sim$ 10 m to $\sim$ 60 m). The different distributions result in jet interactions which result in different dynamical behaviour. By producing synthetic measurements of Rosetta's gas instruments (ROSINA, VIRTIS, MIRO) we can determine the limits of detecting differences of the surface activity distribution.

We have found that ROSINA measurements by themselves cannot detect the differences of our models. ROSINA measurements can therefore by themselves not be inverted to determine the surface emission distribution of the gas sources to a spatial accuracy of better than a few hundred metres. All solutions fitting the ROSINA measurements are hence fundamentally degenerate. Only other instruments with complementary measurements can lift this degeneracy as we will show for VIRTIS and MIRO. In particular we find that MIRO is the only instrument that can distinguish between most of our models. Finally, we have explored the effect of our activity distributions on lateral flow at the surface that may be responsible for some of the observed aeolian features.

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