3-D Direct Simulation Monte Carlo modeling of comet 67P/Churyumov-Gerasimenko

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After deep-space hibernation, ESA's Rosetta spacecraft has been successfully woken up and obtained the first images of comet 67P /Churyumov-Gerasimenko (C-G) in March 2014. It is expected that Rosetta will rendezvous with comet 67P and start to observe the nucleus and coma of the comet in the middle of 2014. As the comet approaches the Sun, a significant increase in activity is expected. Our aim is to understand the physical processes in the coma with the help of modeling in order to interpret the resulting measurements and establish observational and data analysis strategies. DSMC (Direct Simulation Monte Carlo) [1] is a very powerful numerical method to study rarefied gas flows such as cometary comae and has been used by several authors over the past decade to study cometary outflow [2,3]. Comparisons between DSMC and fluid techniques have also been performed to establish the limits of these techniques [2,4]. The drawback with 3D DSMC is that it is computationally highly intensive and thus time consuming. However, the performance can be dramatically increased with parallel computing on Graphic Processor Units (GPUs) [5]. We have already studied a case with comet 9P/Tempel 1 where the Deep Impact observations were used to define the shape of the nucleus and the outflow was simulated with the DSMC approach [6,7]. For comet 67P, we intend to determine the gas flow field in the innermost coma and the surface outgassing properties from analyses of the flow field, to investigate dust acceleration by gas drag, and to compare with observations (including time variability). The boundary conditions are implemented with a nucleus shape model [8] and thermal models which are based on the surface heat-balance equation. Several different parameter sets have been investigated. The calculations have been performed using the PDSC^{++} (Parallel Direct Simulation Monte Carlo) code [9] developed by Wu and his coworkers [10-12]. Simulation tasks can be accomplished within 24–48 hours because of the domain re-decomposition method which optimizes the parallel performance. In this work, we will present the models and simulation results for comet 67P /Churyumov-Gerasimenko, based upon knowledge acquired prior to the wake-up of Rosetta.

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