OPERATIONAL APPROACH FOR THE MODELLING OF THE COMA DRAG FORCE ON ROSETTA

Carlos Bielsa[(1)], **Michael Müller**[(2)] **and Ulrich Herfort** [(2)]
[(1)(2)]*ESA/ESOC Flight Dynamics, HSO-GFS*
Robert-Bosch-Str. 5, 64293 Darmstadt, Germany
+49-6151-90-4253, Carlos.Bielsa@esa.int, Michael.Mueller@esa.int, Ulrich.Herfort@esa.int
[(1)]*GMV*
Isaac Newton 11, P.T.M., 28760 Tres Cantos (Madrid), Spain
+34-91-8072100, cbielsa@gmv.com

Keywords: *Rosetta, coma, comet, drag, atmosphere*

ABSTRACT

The ESA mission Rosetta to 67P/Churyumov-Gerasimenko was designed to complete the most detailed study of a comet ever attempted. When the Rosetta spacecraft (SC) operates in the vicinity of its target comet at low heliocentric distance, the drag force exerted by the coma gas molecules is expected to be in the same order of magnitude as the gravity force from the comet nucleus. Hence, the drag force needs to be estimated in order to predict the SC trajectory.

On the present work, we present the operational approach devised at ESA/ESOC Flight Dynamics to account for the effect of the coma drag on the SC dynamics, a challenge never faced before.

Several physical observables that provide information about the coma state either at the SC position (in-situ observables) or at a distance (remote observables) have been identified. In-situ observables are SC torque measurements derived from change in speeds of onboard reaction wheels and pressure readings from the science payload ROSINA/COPS. Remote observables are images in visible wavelength taken with on-board cameras and observations from payload MIRO (a microwave detector with sub-millimeter channels specifically tuned to detect water remotely).

For the in-situ observables, data is processed in two steps. Measurements collected within time intervals of a few minutes are first reduced to a manageable number of variables specific to the observable. Then, in a second step, the average dynamic pressure within the time interval is derived subject to a set of assumptions. These estimations of in-situ dynamic pressure are stored in a database and used on a regular basis to generate an operational coma drag acceleration file that is used for orbit reconstruction. With this purpose, a model that calculates the coma drag force exerted on the SC for a given coma state and SC configuration, accounting for coma state gradients, shadowing between SC units and different accommodation coefficients, has been implemented. In fact, this model returns not only the coma drag force, but also the torque, which is needed to reduce reaction wheel speed readings to coma gas dynamic pressure.

For the remote observables, measurements are also reduced to a manageable number of variables via specific methods and stored in a database along with information on the conditions under which they were taken.

This database containing reduced measurements of in-situ and remote observables is then used to refine the coefficients of the operational coma model, known as COMA_OP, which has been implemented at ESA/ESOC for the cometary phase of Rosetta. COMA_OP provides the coma gas state at each position and time. The state of gas species is modelled as a superposition of point sources. The spatial distribution of each point source is described by spherical harmonics defined in a frame corrotating with either the sun-comet vector or the comet nucleus. These spherical harmonic coefficients may vary periodically with time to allow for the modelling of diurnal variations. COMA_OP also accounts for varying overall activity with heliocentric distance. The operational coma model will be used both for trajectory propagation and for orbit reconstruction whenever in-situ measurements are either unavailable or uninformative (due to e.g. high attitude rate).

The paper will present the available observables, the reduction methods, the SC drag force and torque model, and the operational coma model COMA_OP. Furthermore, it will describe the operational plan for calibration of payloads, fitting of COMA_OP parameters and validation of the hypotheses underlying the data reduction methods. First ROSINA/COPS gauges are calibrated from torque measurements, then MIRO is calibrated from in-situ measurements. Hypotheses regarding radial evolution of gas and dust velocity and density, as well as coma spatial distribution, are verified against actual measurements. The approach to refine COMA_OP from in-situ and remove observables is tightly bound to the observed distribution and time-stability of the coma structure.