Accurate reconstruction of comet 67P orbit through re-analysis of Rosetta ranging data acquired during proximity operations

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Following its arrival at comet 67P/Churyumov-Gerasimenko in August 2014, the Rosetta spacecraft successfully navigated in its proximity for two years, using a combination of Earth-based astrometric and radiometric tracking data as well as space-based optical navigation data.

Depending on the mission phase, the orbital navigation system was tasked with the simultaneous estimation of both spacecraft and comet state, in addition to several other physical parameters including amongst others the comet rotational state, its gravitational field and the body-fixed coordinates of surface landmarks.

Estimating the heliocentric trajectory of 67P has proven to be challenging, due to the lack of reliable models to take into account the non-gravitational accelerations acting on the comet (particularly close to perihelion) and to occasional degradations of the ranging observables caused by geometrical constraints (solar conjunctions).

The accuracy of the resulting comet heliocentric trajectories, which show discontinuities in the order of tens of kilometers between consecutive short-arc solutions, was sufficient for spacecraft proximity operations, where navigators are mostly concerned by the relative comet/spacecraft position. However, a continuous and more accurate orbital solution is strictly coupled with the development of analytical models for non-gravitational accelerations and comet outgassing for which the Rosetta mission represents an ideal test case.

The work presented here represents a joint effort between academic institutions and ESA’s Flight Dynamics team to improve the accuracy of 67P’s orbit, by re-analyzing the radiometric data over long time scales for the whole duration of Rosetta proximity operations at comet 67P.

Details on the orbit determination process and filter implementation will be presented, together
with a discussion on the achieved formal uncertainties and on the observables' residuals.