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BepiColombo's geodesy and relativity experiments from an extended mission

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The Mercury Orbiter Radio science Experiment (MORE) of the ESA-JAXA BepiColombo mission to Mercury consists of ground and onboard instrumentation enabling a highly stable, multi-frequency radio link at X and Ka band (8.4 and 32.5 GHz). Range rate measurements obtained from this advanced radio link will be unaffected by plasma noise and are expected to attain accuracies of 3 micron/s (at 1000 seconds integration time) at nearly all elongation angles. Thanks to a novel wideband ranging system, based on a 24 Mcps pseudo-noise modulation, the spacecraft range will be measured to an accuracy 20 cm (two-way). The MORE investigation will greatly benefit from a direct measurement of the vectorial non-gravitational accelerations by means of the Italian Spring Accelerometer (ISA).

The high quality radio-metric observables will provide a precise reconstruction of the spacecraft orbit and an accurate estimation of the gravity field and rotational state of the planet. Thanks to the dedicated onboard instrumentation, MORE is expected to improve significantly the already outstanding MESSENGER results, limited by plasma noise and the difficulty of modeling non-gravitational accelerations. In addition, BepiColombo will carry out tests of general relativity by reconstructing the orbit of the planet and the propagation of photons in the solar gravitational field. Indeed, since the orbit of Mercury is affected more than any other planets by relativistic effects, the relativity experiment aims at improving the determination of several Post-Newtonian (PN) parameters. Further physical parameters such as the rate of change of the gravitational constant G and the oblateness factor J2 of the Sun will be estimated as well.

Several numerical simulations of the MORE experiment have been carried out over the past years. In this work we present a new set of simulations under the latest mission scenario and instrument performances, as obtained from ground tests of the instrumentation. Our simulation setup solves simultaneously for gravity harmonic coefficients, rotational state elements and relativistic PN parameters. The paper reports on the results obtained under the nominal, one year, mission duration, and shows the improvements attained by an extended mission of one or two years. Indeed, the pericenter of BepiColombo's planetary orbiter will drift from 15 degree N to 13, 41, 70 degree S respectively in one, two and three years. In addition the pericenter altitude will decrease from 480 to 250 km in three years. This will allow a more comprehensive and homogeneous reconstruction of the gravity field and rotational state of Mercury. We show also that an extended mission would be greatly beneficial also to the relativity experiment.