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Numerical simulations of a geodetic orbital experiment for future mission to Mars

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In the context of the preparation of future ESA missions to Mars such as MEMO, ExoMars, or NEXT, we study the opportunities to improve our knowledge on the interior of Mars from a geodetic experiment onboard an orbiter around Mars. This consists in monitoring the fine perturbations of the orbiter motion from the measurement of Doppler shifts of an X-band (7.1/8.4 Ghz) radio-link between this orbiter and Earth's tracking stations. Previous missions, like MGS, MRO, Mars Odyssey, or MEX, have already exploited such measurements to improve the determination of Mars' time variable gravity field (J2 and J3 zonal harmonics) and of the k2 tidal Love number. However, the solutions for these parameters still suffer from a lack of precision to better constrain the interior model of Mars (state and size of the core), and the seasonal CO2 mass exchange between the polar caps and the atmosphere. The ability to improve the resolution of these parameters from an orbiter depends mainly on the characteristics of its orbit (altitude, inclination and eccentricity). A new orbiter with typical altitude range of 130x1000 km and inclination of 77 degrees, complementarily with usual near-circular near-polar orbits (e.g., for present NASA's MRO orbiter), offers the opportunity of such improvement. In this study, we have first performed numerical simulations of such orbiter-Earth Doppler measurements, using the GINS software developed by CNES and further adapted at ROB for planetary geodesy applications. We have studied our ability to retrieve time variable J2 and J3, as well as k2 from these simulated data depending on the Doppler noise level and the occurrence of tracking data from the Earth. Secondly, we have simulated, at another observational period, additional Doppler data of a second orbiter with a MRO-like altitude range but

with an inclination of 50 degrees. We show that these two data sets although at different timing bring complementary information about J2 and J3 harmonics, and thus improve by a factor of up to 10 the determination of these parameters. Further simulations will take into account additional perturbing effects (such as those related to the non-gravitational forces acting on the orbiter) and the addition of Lander(s)-orbiter Doppler measurements in order to detect the signature of a possible liquid core on the nutation of Mars' rotation axis and on the k2 Love number.