Preliminary results of one Martian year of observations from the radio-science experiment of InSight, RISE.

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Introduction: The Interior Exploration using Seismic Investigations, Geodesy, and Heat Transport (InSight) mission provides a unique opportunity to improve our knowledge of Mars' interior via the Rotation and Interior Structure Experiment (RISE) [1]. RISE measures the Doppler shift of radio transmissions from InSight to NASA's Deep Space Network (DSN) on Earth. These Doppler measurements, via iteration with orbit determination and analysis software (GINS and MONTE), yield the rotation and orientation of Mars, which provide information on the planet's interior.

RISE Measurements: The ongoing RISE experiment provides X-band Doppler measurements almost daily since day 1 (~45 min of observation per session in average) by using its two fixed-pointing horn-shape medium-gain antennas. The InSight data set used for this study consists of 21,091 data points, compressed over 60s (i.e. 335 hours of tracking), and acquired over one Martian year (687 days) from November 27th, 2018 to October 14th, 2020. Between July 16th 2019 and Oct. 18th 2019, the Sun-Earth-Planet (SEP) angle was lower than 15º, inducing significant plasma noise on these measurements, which have therefore been excluded from our analysis. The retained measurements have a very high accuracy of 1.8 mHz for the 60s data provided by the 70m-dish DSN antennas and 2.3 mHz for the 34m-dish stations.

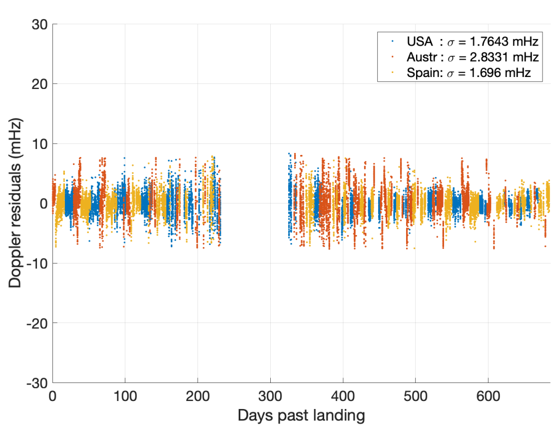

Figure 1: Postfit Doppler residuals as a function of the DSN complex used.

Mars Precession determination and Moment of Inertia (MOI): The gravitational torque exerted by the Sun on the equatorial bulge of the rotating Mars causes a precession of the axis of rotation in space. The spin axis completes one rotation about the normal to the orbit plane in about 171,000 years. Because the precession rate is inversely proportional to the polar moment of inertia, which is a key parameter to constrain interior models, we use RISE measurements to refine its determination. The set of RISE data used in the present study spans over one Martian year, which suffices to determine the strong signal of the precession rate in RISE Doppler data. Refined value is in good agreement with the recently published estimates of -7603.9±1.3 mas/year from orbiting spacecraft [2] and of -7605±3 mas/year from the combination of InSight first Earth year of data with previous data from the Viking-1 lander, Mars Pathfinder, and Opportunity missions [3]. The MOI is an important constraint for the interior structure of the planet and in particular for the mass distribution within the crust and upper mantle. When combined with seismic constraints about the structure of the crust [4,5], the MOI helps to further refine the set of global average thickness models inferred from seismic data [4,6].

Mars nutation and Liquid Core Properties: Variations in the torque due to the relative positions between Mars and the Sun lead to periodic time variations of the rotation axis in space, the so-called nutations. The nutation amplitudes are affected by the presence of a liquid core [1]. Using RISE Doppler measurements, we have been able to detect for the first time the liquid core contribution in Mars orientation variation. Besides confirming the liquid state of the core, our nutation parameter estimates allow us to constrain Mars core size and density. Our independent results are in good agreement with core size and density inferred from Mars tidal Love number, k_2, estimated from orbiter [2] and from the core radius assessment provided by the Seismic Experiment for Interior Structure (SEIS) [6].

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