THE MARTIAN INTERIOR STRUCTURE FROM LANDED PROBE DOPPLER TRACKING.

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Introduction: The InSight spacecraft will land on Mars in 2016 carrying a seismometer and other geophysical instruments for exploration of the interior structure of the planet [1]. One of the InSight investigations is the Rotation and Interior Structure Experiment (RISE), a Radio Science experiment utilizing precision Doppler tracking. After landing, the stationary probe will begin a science phase that includes a communication link at ~8 GHz (X-band) with the Deep Space Network. This link serves Radio Science as well as back-up emergency communications; the primary communications in the landed phase is via UHF relay. The objectives of RISE include constraining the interior models of Mars by measuring the change in the spin axis direction as a function of time. This measurement yields estimation of the precession, the long term changes about the ecliptic pole, which is proportional to the polar moment of inertia, and the nutation, the short-term motion, primarily 1/2 and 1/3 of a martian year, which is a function of core's moment of inertia.

Description: The Interior Structure Experiment infers the planetary interior structure from its effects on the orientation of Mars' rotation axis in inertial space. The precession, nutation, and polar motion of Mars result from the interaction of the interior mass distribution with the gravity of the Sun. RISE provides improved estimates of these motions by analyzing a stable two-way coherent radio link between the spacecraft and the Deep Space Network. Improvements over previous missions [2,3] will result from the better tracking accuracy as well as the increased total time span between the first and last missions, Viking and InSight.

For precision tracking of radio links between the DSN and the spacecraft, RISE uses the X-band communications transponder to obtain Doppler measurements several times per week. These accumulate over the long duration of the mission and can then be used to obtain Mars' rotation behavior: precession, nutations, and Length of Day/polar motion to obtain information about Mars' interior. At the same time, measurement of variations in Mars' rotation rate reveals variations of the moment of inertia due to seasonal mass transfer between the atmosphere and polar caps.

Precession measurements, together with those of nutations and tides, improve the determination of the MOI of the whole planet and thus the radius of the core. For a range of possible compositions, the core radius is expected to be determined with a precision of a few tens of kilometers (currently ±200 km). A precise measurement of variations in the spin axis also enables an independent and more precise determination of the size of the core via core resonances in nutation amplitudes. The amplification of this resonance depends on the size, MOI, and flattening of the core. For a large core, the amplification can be very large, ensuring the detection of the free core nutation and determination of the core MOI.

References:

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