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Rotation and internal dynamics of terrestrial planets

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In the last decades, several missions and observations have brought new insight on the inner structure of the terrestrial planets. This information is a big challenge for the planet interior models; these data are also our best chance to improve our knowledge of the interior. Data obtained through new space missions are the basis of the future progress in this field. Classically, as done for the Earth, the interior models are constrained through seismic data provided from an extended network of seismometers. However, for planets, in the absence of such a network, gravitation and rotation studies are the most efficient ways to learn about the interior of the planets. Practically, our study is based on the analysis of the precise orbits of spacecrafts around the planets and on the positions of landers. Experiments on the planet Mars and Mercury will allow us to answer some of the most debated questions of the moment.
On Mars, we plan in particular for the LaRa (Lander radioscience) instrument to be part of the Humboldt Payload (on the fixed platform lander) of the ExoMars ESA mission. LaRa is a coherent transponder using one uplink and one downlink in X-band. LaRa will measure the variation of Mars' rotation rate (related to the length-of-day) and the orientation of Mars' rotation axis in space (precession and nutations), by measuring Doppler shifts resulting from the motion of Mars relative to the Earth, through monitoring a radio signal between the ExoMars lander and the tracking stations from ESA (ESTRACK stations) and NASA (the Deep Space Network, DSN) on Earth. The primary objective of LaRa is a precise measurement of precession, nutations, and length-of-day. Comparing the data with theoretical modeling allows inferring knowledge on Mars' interior and on the global circulation in its atmosphere. Precession and nutations are induced by the well-known gravitational forcing of the Sun on Mars. Nutations depend on the internal properties of Mars, in particular on the state and dimension of the core. Length-of-day variations are deviations from the uniform rotation rate of the planet. They are mainly related to the dynamics of the geophysical fluids of the system, mainly the atmosphere of Mars. The seasonal condensation/sublimation of the icecaps induces a large change in the length-of-day at the seasonal periods. These measurements at Mars will be compared with those of the Earth. The BepiColombo mission to Mercury will also allow measuring the rotation of this small planet and in particular the libration, which will also bring insight on the interior of Mercury.