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Interior of Mars from spacecraft and complementary data.

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Mars, as Earth, Venus and Mercury is a terrestrial planet having, in addition to the mantle and lithosphere, a core composed of an iron alloy. This core might be completely liquid, completely solid or may contain a solid part (the inner core) and a liquid part. The existence of a magnetic field around a planet is mainly explained by the presence of motions in the liquid part in the core. The absence of a magnetic field does not help in constraining the state of the core as it might be completely solid or completely liquid but the motion (convection) might not be sufficient to maintain it, or even contain a growing inner core inside a liquid core composed of iron or Nickel and a percentage of light element corresponding to the eutectic composition (no precipitation). The planet Mars is smaller than Earth. It has evolved differently. We know for the Earth that the core is liquid and that the inner core is forming by precipitation of iron. For Mars spacecraft observation of the gravity field and its time variation allow us to obtain the effect of mass repartition, and in particular those induced by the solid tides. These tidal deformation of the planet are larger for a planet with a liquid core than for a completely solid planet. Recent spacecraft orbiting around Mars (MGS, Mars Odyssey, MRO, Mars Express) have allowed to obtain the k2 tidal Love numbers. This measurement is rather at the limit of what the observation can tell us but seems to indicate that Mars has a liquid core. The absence of a present-day global magnetic field places Mars in the situation where the inner core is not yet forming or has reached the eutectic.
Physical observation of the planet other than tides also allow us to obtain information about the interior of Mars: its rotation and orientation changes. Planetary rotation can be separated into the rotation speed around an axis and the orientation of this axis (or another axis of the planet) in space. Most of us know that the rotation of a boiled egg noticeably differs from that of a raw egg. This simple observation shows that information on the inside of an object can be obtained from its rotation. The same idea applies to the rotation of celestial bodies. Their rotation changes and orientation changes provide information on the interior. For Mars, as for the Earth, it is mainly the changes in the orientation that are important to characterize their interiors, the length-of-day variations being mostly related to atmospheric angular moment transfer to the solid planet. The orientation changes are called precession, the long-term change, and nutation, the periodic wiggly short-term changes that are the most interesting to obtain information about the core. Nutations have up to now only been unambiguously observed for the Earth, but the InSIGHT (Interior exploration using Seismic Investigations, Geodesy, and Heat Transport) NASA mission to be launched in 2016, will carry out an X-band transponder enabling us to do Doppler measurements on the motion of Mars with respect to Earth, and therewith to determine the nutations and the interior structure of Mars.