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Crosslink Occultations for probing the planetary atmosphere and ionosphere of Mars

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Abstract

Radio waves propagating through a refractive medium like a planetary atmosphere or ionosphere experience a phase change that can be used to study the refraction of the media along the signal ray path. The refractivity derived from these phase measurements can be used to obtain height profiles of electron density in the ionosphere and neutral number density, temperature, and pressure in the lower atmosphere.

1. Earth Occultations for Sounding Planetary Atmospheres and Ionospheres

The first such experiment was performed at Mars during the flyby of the Mariner 4 spacecraft [1]. The high accuracy of the retrieved profiles established radio occultation experiments as a powerful tool for the study of planetary environments. Since then, these experiments have become an essential component of almost all flyby and orbital missions. They were performed in Earth occultation geometry where a signal propagates through the planetary environment before and after the spacecraft is occulted by the planetary disk as seen from the Earth. The planet-spacecraft-Earth geometry restricts the measurements to so called occultation seasons, dependent on the planetary constellations and the spacecraft orbit [2,3]. Earth occultations at the outer planets are also limited to solar zenith angles near the day-night terminator.

2. Crosslink Occultations at Earth

On Earth, occultation experiments became feasible only since the availability of numerous Earth-orbiting satellites, e.g. [4]. Low Earth orbiting spacecraft (LEOs) can be used combined with satellites of the Global Navigation Satellite System (GNSS) to study the Earth's environment (so-called crosslink occultations). This results in hundreds of occultation opportunities every day. These crosslink occultations require a stable frequency reference on both ends of the radio link.

3. Crosslink Occultations at other Planets

The first (and only) crosslink occultation experiments on other planets were successfully performed at Mars between the Mars Odyssey (MO) spacecraft and the Mars Reconnaissance Orbiter (MRO) [5,6]. These occultations are a powerful tool to retrieve highly accurate profiles. These crosslink occultations have significant advantages: they are not limited to occultation seasons, have a high signal-to-noise-ratio, and can retrieve observations at virtually all solar zenith angles. The capabilties of these occultations are studied for Mars Express and the Trace Gas Orbiter (TGO).

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