An Incoherent Scatter Radar Mission to Mars (ISRMM)

Overview

We propose a lander-based implementation of incoherent scatter radar mission to Mars, building upon an instrument technique that has been extensively proven on Earth. By measuring the thermal properties of the Martian atmosphere in regions that orbiting spacecraft cannot explore, the ISRMM will determine the abundance and temperatures of ionospheric species that directly affect atmospheric composition, dynamics, and escape rates. This will allow identification of heating sources and sinks that determine Mars' atmospheric energy budget. Pragmatically, understanding the properties of the ionosphere will facilitate surface-to-space communications, particularly during entry, descent, and landing, and will aid in the interpretation of data from past and present orbiting spacecraft.

Operations

The ISRMM concept requirements will likely require utility of a Mars Lander with an EDL design similar to that of MSL and/or Mars2020. Operations engineering teams would likely be based at JPL.

Instruments

The ISRMM would require an unfurlable antenna utilizing Martian air as the bulk of the antenna area. The electronic components would be included with the solar panel plates for efficiency and would require minimal power. Dust-mitigating technologies and power optimization technologies would be of relevance. This abstract is to solicit: (1) most updated options for such technologies, as well as (2) options for extremely low power instrumentation to be piggy-backed onto the lander design (e.g., wind and temperature instrumentation).

Science Objectives

A successful ISRMM design would be capable of measuring routine measurements of electron density (N_e), electron temperature (T_e) and, most critically, ion temperature (Ti) in the lower ionosphere of Mars. Remote sensing measurements from orbiting spacecraft have been able to obtain N_e measurements with some cadence, yet T_e and T_i measurements below orbiting spacecraft altitudes, and outside of the two Viking Lander measurements, remain unknown.

Measurements of T_e and T_i in the lower ionosphere would enable understanding the properties that contribute to heating sources and dissipation, electrodynamical variability, and planetary loss to space. These same properties affect radio communication. The proposed mission concept represents an optimal approach for a facility that can make routine measurements of the lower ionosphere from the surface of Mars, and would therefore provide seminal measurements of plasma properties in a presently elusive and dynamical region of the atmosphere.

Needed Technologies with current TRL

The ISRMM concept would require development of a miniaturized, low-power, radar (hardware and software component) to be built into solar panels as well as dust-mitigating technology to accommodate solar panel utility. Performance metrics for the radar are shown in Figure 1. At present, components of the ISRMM design include a Deployable Array Radar Aperture hardware component (current TRL 2), and a low size weight and power (SWAP) Mars Radar software component (current TRL 2). Dust mitigation techniques exist and novel low-SWAP technologies would be of interest.

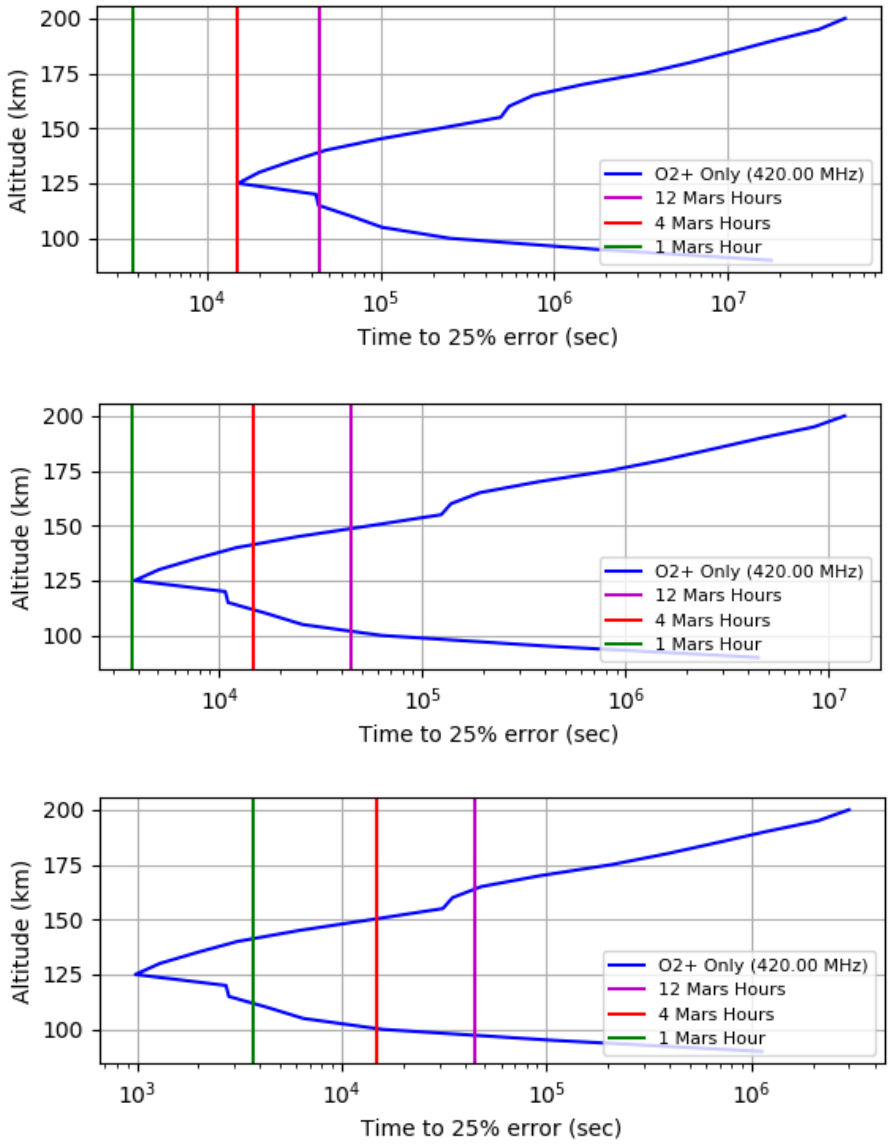

Figure 1. Performance estimates, based on Fig. 1, for ISRM. Single sub-array (top) uses 361 elements, dual sub-array (middle) uses 722 elements, and quad sub-array uses 1444 elements. Vertical lines indicate variable integration times of 1 hr (green), 4 hrs (red), and 12 hrs (purple) for reference. The intersection points of each vertical line with the O_2^+ (blue) measurement speed estimate shows the range of altitudes where plasma density and temperature profiles can be achieved at 25% uncertainty. Longer integration times translate to wider altitude coverage.

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