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The New Frontiers Saturn PRobe Interior and aTmosphere Explorer (SPRITE) Mission Proposal

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Abstract

The 2013-2022 Planetary Decadal Survey Vision and Voyages [1] identified Saturn as a target of high priority for a New Frontiers probe mission concept. To better constrain models of Solar System formation, giant planet formation and evolution, and to provide an improved context for understanding exoplanetary systems, fundamental measurements of Saturn including noble gas abundances, isotope ratios of hydrogen, carbon, oxygen, and nitrogen, and measurements of the interior structure including thermal structure, dynamics, and clouds are needed. Of particular importance is helium, needed to understand the formation history and thermal evolution of Saturn, and water since it is thought that the heavy elements were delivered to Saturn by water-bearing planetesimals.

The Saturn PRobe Interior and aTmosphere Explorer (SPRITE) Mission concept would consist of a Carrier Relay Spacecraft (CRSC) and an entry probe that descends to at least ten bars. The primary payload of the SPRITE probe is proposed to comprise two spectrometers – a Quadrupole Mass Spectrometer and a Tunable Laser Spectrometer, and an Atmosphere Structure Instrument including a simple nephelometer and a Doppler Wind Experiment for measuring and characterizing the thermal, cloud, and dynamical structure of Saturn's troposphere. The Atmospheric Structure Instrument also includes accelerometers to measure entry accelerations from which the probe entry and descent trajectory can be reconstructed and the thermal structure of the upper atmosphere characterized. The solar powered CRSC carries a Multi-Channel Imager for pre-entry imaging of the probe entry location, and to provide global context imaging for the probe measurements.

SPRITE is proposed to launch in late November 2024 launch and follows an Earth-Venus-Earth-Earth gravity assist trajectory to reach Saturn in November, 2034. The SPRITE probe enters Saturn's atmosphere at a relative velocity of ~27 km/s, experiencing a peak heat flux near 3000 W/cm^2 and a peak deceleration up to 45 g's. The aeroshell is released above the tropopause and the descent science sequence is initiated, permitting up to 2 hours for the probe to pass through 10 bars. To ensure low risk data return, the descent probe is a fully-redundant dual-channel design powered by primary batteries. Once the probe science data is collected by the flyby Carrier Relay Spacecraft, the probe data and Carrier imaging data downlinked to Earth multiple times through the Deep Space Network.

References

[1] "Vision & Voyages for Planetary Science in the Decade 2013-2022," National Academies Press, Mar. 7, 2011.