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The Saturn PRobe Interior and aTmosphere Explorer (SPRITE) Entry Probe Mission Concept

David H Atkinson (1), Amy Simon (2), Don Banfield (3), Sushil Atreya (4), Jordana Blacksberg (1), Will Brinckerhoff (2), Anthony Colaprete (5), Athena Coustenis (6), Leigh Fletcher (7), Tristan Guillot (8), Mark Hofstadter (1), Jonathan Lunine (3), Paul Mahaffy (2), Marl Marley (5), Olivier Mousis (9), Tom Spilker (10), Melissa Trainer (2), and Chris Webster (1)

(1) Caltech/JPL, Pasadena, United States (david.h.atkinson@jpl.nasa.gov), (2) NASA Goddard Space Flight Center, (3) Cornell University, (4) Univ. Michigan, (5) NASA Ames Research Center, (6) LESIA, Observ. Paris-Meudon, CNRS, Paris Univ., France, (7) Univ. Leicester, (8) Observatoire de la Cote d'Azur CNRS / Laboratoire Cassiopée, (9) Laboratoire d'Astrophysique de Marseille, (10) Independent Consultant

To improve models of Solar System formation, as well as to provide an improved context for exoplanet systems, measurements of the atmospheric composition and structure, and processes within the atmospheres of the giant planets are needed. In particular, measurements of the abundances of noble gases and isotope ratios of hydrogen, carbon, oxygen, and nitrogen, as well as the thermal profile, cloud structure, and dynamics of Saturn are necessary. The SPRITE (Saturn PRobe Interior and aTmosphere Explorer) entry probe mission concept addresses these important science priorities and would provide ground truth for remote sensing to improve understanding of Saturn's interior structure and composition, and (by proxy) those of extrasolar giant planets.

The SPRITE Mission concept consists of a Carrier Relay Spacecraft (CRSC) and an entry probe descending to at least ten bars in about 90 minutes. The primary scientific instrument payload of the SPRITE probe would 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 trajectory and descent location would be reconstructed and from which the thermal structure of the upper atmosphere would be characterized. The solar powered CRSC carries a Multi-Channel Imager for pre-entry imaging of the probe entry location, and to provide local and global context imaging for the probe measurements.

SPRITE would follow an Earth-Venus-Earth-Earth gravity assist trajectory to reach Saturn in ten years. The SPRITE probe would enter Saturn's atmosphere at a relative velocity of $\sim$27 km/s, experiencing a peak heat flux near 3000 W/cm^2 and a peak deceleration up to 45 g's. The aeroshell would be released above the tropopause, initiating the descent science sequence and permitting up to 2 hours for the probe to reach and pass through 10 bars. To ensure low risk data return, the descent probe design is fully-redundant with a dual-channel telecommunication system powered by primary batteries. After the probe science data is collected by the flyby Carrier Relay Spacecraft, the probe data and Carrier imaging data would be downlinked to Earth multiple times through the Deep Space Network

In the context of giant planet science provided by the Galileo, Juno, and Cassini missions to Jupiter and Saturn, a small, relatively shallow Saturn probe capable of measuring abundances and isotopic ratios of key atmospheric constituents, and atmospheric structure including pressures, temperatures, dynamics, and cloud locations and properties not accessible by remote sensing would serve to test competing theories of solar system and giant planet origin, and chemical and dynamical evolution.

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