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A Shallow Probe Mission to Saturn

Anthony Colaprete (1), Thomas R. Spilker (2), David Atkinson (3), Linda Spilker (2), Tibor Balint (2), Athena Coustenis (4), Robert Frampton (5), Reta Beebe (6), and Kim Reh (2)

(1) NASA Ames Research Center, Moffett Field CA, United States (tonyc@freeze.arc.nasa.gov), (2) Jet Propulsion Laboratory, MS 301-165, Pasadena, United States (thomas.r.spilker@jpl.nasa.gov, 001-818-393-9815), (3) Dept. of Electrical and Computer Engineering, Univ. of Idaho, Moscow ID, USA, (4) LESIA, Observatoire de Paris-Meudon,Meudon Cedex, France, (5) The Boeing Company, Huntington Beach CA, USA, (6) Dept. of Astronomy, New Mexico State Univ., Las Cruces NM, USA

To understand the origin and evolution of the solar system and the giant planets, the formation of giant planet atmospheres, and to provide a valuable link to emerging studies of extrasolar planets, comparative studies of the atmospheres of the gas and ice giant planets are needed. Within the deep atmospheres and interiors of the giant planets, material from the epoch of solar system formation can be found. Some of these materials are expected to be unprocessed and therefore reflect the composition of the protosolar nebula at the time and location at which each planet formed, while some materials will have undergone extensive processing reflecting processes interior to the planet.

A single planet cannot be understood in isolation. Our understanding of Jupiter and any of the other giant planets is inseparably coupled to comparable studies of all the giant planets. The Galileo orbiter and probe mission provided both remote sensing and in situ studies of Jupiter. To provide an important comparative planetology context for the Galileo Jupiter results, a comparable understanding of Saturn and the ice giants Uranus and Neptune is needed. When coupled with the Galileo orbiter/probe studies of Jupiter and the Cassini remote sensing studies of Saturn, a Saturn entry probe mission will provide a solid comparative planetology basis for improved understanding of both Jupiter and Saturn, and an important stepping stone to understanding the ice giant planets Uranus and Neptune and the formation and evolution of the solar system.

The fundamental measurements for a Saturn entry probe mission are the abundances of the noble gases He, Ne, Ar, Kr, Xe and their isotopes, and abundances of other key isotopic ratios 4He/3He, D/H, 15N/14N, and 13C/12C. Detection and measurement of disequilibrium species such as CO, PH3, AsH3, and GeH4 can provide evidence for deeper internal processes. A precise determination of the He abundance, and comparison with the He abundance measured by the Galileo probe at Jupiter, is needed to constrain models of giant planet formation and of internal evolutionary processes (such as helium sedimentation) thought to generate internal heat in the gas giants.

Carbon in the form of CH4 does not condense at Saturn and is therefore expected to be well-mixed throughout the atmosphere, and sulfur is expected to be sequestered in and below an ammonium hydrosulfide (NH4SH) cloud at 4-5 bars. Since carbon, the noble gases and key isotopes are expected to be well-mixed at levels of several bars, and sulfur is expected to be well-mixed below the 4-5 bar NH4SH cloud, the abundances of the noble gases, isotopes, carbon, and sulfur, as well as gradients of oxygen in the form of water and nitrogen below the ammonium hydrosulfide cloud, can be measured by entry probes to pressures of 5-10 bars.

A shallow entry probe mission to Saturn with a science complement consisting of a Neutral Mass Spectrometer, Atmospheric Structure Instrument, and ultrastable oscillator could measure the composition as well as the thermal structure, clouds, and dynamics of Saturn's upper troposphere.