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ICY GIANT PLANET EXPLORATION: ARE ENTRY PROBES ESSENTIAL?

Abstract

"Flyby, orbit, land" has been the guiding philosophy of the exploration of the solar system. This systematic approach has been highly successful in addressing the most fundamental questions of origin, evolution, and habitability of the solar system. For the giant planets, entry probes take the place of landers since the land of the gaseous/icy giant planets lies some tens of thousands of kilometers below their cloud tops, hence impractical to reach. Fortunately, the volatiles of the core were mixed into the accessible upper troposphere during the accretionary heating phase. Entry probes to relatively shallow depths are thus capable of determining the abundances and isotopes of the "heavy elements" (heavier than helium) by measuring those volatiles. The resulting data provide key constraints to the formation and evolution models [1]. Entry probes add complexity and cost to spacecraft missions, however. Yet they are essential, as the above data can only be obtained in situ at probe depths. This was the rationale behind NASA's 1995 Galileo probe at Jupiter and the Saturn Probe mission in NASA's New Frontier 4 list of science themes. Saturn probe proposals to ESA's Cosmic Vision Program are similarly inspired. In 2016, NASA funded an Ice Giant Planets Study to recommend a comprehensive set of science objectives and goals, and further to investigate the feasibility of and mission architectures for accomplishing them in the 2023-2033 decade. The most highly rated mission from that study is an orbiter with a probe to either Uranus or Neptune [2]. While remote sensing observations from the orbiter will yield composition, structure and distribution of the neutral and charged particles in the magnetosphere and upper atmosphere, the entry probe will determine abundances and isotopic ratios of H, C, and possibly N and O, together with noble gases (He, Ne, Ar, Kr, Xe). The noble gases are crucial to the formation models, and their values from probe location would represent global values as they are unaffected by meteorology, dynamics and chemistry. In this presentation we will elaborate on these issues and briefly discuss possible scenario/s for a mission to the icy giant planets, with particular attention to probes. [1] Atreya S.K., et al. (2018). The Origin and Evolution of Saturn, with Exoplanet Perspective, in Saturn in the 21st Century (K. H. Baines, et al., eds.), Cambridge University Press (presently at arXiv:1603.02852. [2]Ice Giants Pre-Decadal Survey Report, NASA-JPL ID-100520, 2017, http://www.lpi.usra.edu/icegiants/