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The Hera Saturn Entry Probe Mission Concept

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Abstract

1. Introduction

A fundamental goal of solar system exploration is to understand the origin of the solar system, the initial stages, conditions, and processes by which the solar system formed, how the formation process was initiated, and the nature of the interstellar seed material from which the solar system was born. Key to understanding solar system formation and subsequent dynamical and chemical evolution is the origin and evolution of the giant planets and their atmospheres. Additionally, the atmospheres of the giant planets serve as laboratories to better understand the atmospheric chemistries, dynamics, processes, and climates on all planets in the solar system including Earth, offer a context and provide a ground truth for exoplanets and exoplanetary systems, and have long been thought to play a critical role in the development of potentially habitable planetary systems.

Remote sensing observations are limited when used to study the bulk atmospheric composition of the giant planets of our solar system. A remarkable example of the value of *in situ* probe measurements is illustrated by the exploration of Jupiter, where key measurements such as noble gases abundances and the precise measurement of the helium mixing ratio have only been made available through in situ measurements by the Galileo probe. Representing the only method providing ground-truth to connect the remote sensing inferences with physical reality, *in situ* measurements have only been accomplished twice in the history of outer solar system exploration, via the Galileo probe for Jupiter and the Huygens probe for Titan. *In situ* measurements provide access to atmospheric regions that are beyond the reach of remote sensing, enabling the dynamical, chemical and aerosol-forming processes at work from the thermosphere to the troposphere below the cloud decks to be studied. The Hera Saturn entry probe mission was proposed to the European Space Agency in response to the Medium Class mission announcement of opportunity and is currently under consideration as an ESA M-class flight mission. The proposed Hera mission comprises an atmospheric entry probe built by the European Space Agency with contributions from NASA, to be released into the atmosphere of Saturn by a companion solar-powered Saturn Carrier-Relay spacecraft (CRSC) possibly provided by NASA. The CRSC would deliver the probe to the Saturn entry interface point and subsequently act as a relay station to receive the probe science telemetry for recording and later transmission to Earth. Hera would descend under a sequence of parachutes to depths of at least 10 bars in approximately 75 minutes. By probing deep into the cloud-forming region of the troposphere to locations where certain cosmogenically abundant species are expected to be well mixed and far below regions accessible to remote sensing, Hera would measure the atmospheric composition, most notably noble gases and key isotopes not accessible by remote sensing, as well as the thermal and dynamical structure of Saturn's atmosphere at the probe descent location.

The battery-powered Hera probe would be designed from ESA elements with contributions from NASA, with the Carrier Relay Spacecraft possibly supplied by NASA. The only major subsystem to be provided either by direct procurement by ESA or by contribution from NASA is the probe entry aeroshell and thermal protection system.

Following the example set by the highly successful example of the Cassini-Huygens mission, the Hera probe science team would comprise an international science team and would carry European and American instruments, with scientists and engineers from both agencies and many affiliates participating in all aspects of mission development and implementation. The basic Hera probe science payload would include a Mass Spectrometer to measure the bulk composition of Saturn's atmosphere, an Atmospheric Structure Instrument to measure the thermal structure and stability of Saturn's atmosphere, and a Doppler Wind Experiment to measure the dynamics of Saturn's atmosphere. Other possible instruments in the Hera scientific payload include a Net Flux Radiometer to measure the energy balance of the Saturn atmosphere and a Nephelometer to measure cloud location and structure.

In the context of giant planet science provided by the Galileo, Juno, and Cassini missions to Jupiter and Saturn, the Hera Saturn probe would provide critical measurements of composition, structure, and processes that are not accessible by remote sensing. The results of Hera would help discriminate between competing theories of solar system and giant planet origin, chemical, and dynamical evolution.

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