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The atmospheric structure of the Ice Giant planets from *in situ* measurements by an entry probe

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Abstract

Atmospheric entry probes offer a unique opportunity for sounding atmospheric regions not reachable from remote sensing observations. *In situ* measurements during the entry and descent allow for investigating the atmospheric composition, structure and dynamics down deep into the atmosphere (e.g. Galileo probe at Jupiter [1], Huygens probe at Titan [2]).
In the framework of the opportunity for a NASA-ESA joint mission to Uranus, Neptune and their moons, we are proposing an Atmospheric Structure Instrument (ASI) for an entry probe at the Ice Giant planets.

1. Introduction

The atmosphere of Uranus and Neptune, the Ice Giants of our Solar System, were probed by the Voyager 2 during its flyby in 1986 and 1989 respectively. The atmospheric temperature profiles were primarly retrieved from the Voyager radio occultations [3], [4]; while both ground based and Voyager thermal infrared, solar and stellar occultation observations further constrained the thermal structure (e.g. [5]).

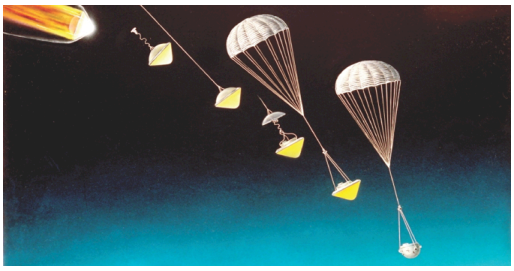

Figure 1: Entry, Descent into the Ice Giant atmosphere

An atmospheric entry probe will allow for sounding the atmosphere of the Ice Giants down deep, below the 1 bar level, investigating the atmospheric composition, structure and dynamics by *in situ* measurements.

2. The Ice Giant ASI: science objectives and expected results

On the heritage of the Huygens ASI experiment at Titan [6,7], the Ice Giant ASI will consist of a multi sensor package designed to measure the physical quantities characterizing the Uranus' or Neptune's atmosphere during the entry and descent of the probe into the planet. The key measurements will be acceleration, pressure, temperature and electrical properties all along the probe descent down deep into the atmosphere in order to investigate the atmospheric structure, dynamics and electricity.

The atmospheric profile along the probe trajectory will be retrieved by the measurements of the deceleration of the entry probe and by direct measurements of the pressure and temperature during the descent under parachute. The resulting atmospheric thermal structure constrains the atmospheric stability, dynamics and its effect on the atmospheric chemistry.
The variations in the density, pressure and temperature profiles provide information on the atmospheric stability and stratification, on the presence of wind, thermal tides, waves and turbulence in the atmosphere. The estimation of the temperature lapse rate can be used to identify the presence of the condensation and aerosols and cloud layers, to distinguish between saturated and unsaturated, stable and conditionally stable regions. Measurements of the atmospheric electrical properties along the descent could contribute to the

study of the moist convective processes, clouds formation and characterization, and allow for detection of possible electrical discharges, i.e. lightning. Moreover IG-ASI will contribute also to the analysis of the atmospheric composition, providing the primary engineering function by establishing the descent trajectory, and probe altitude and velocity for correlating all the other probe experimental data.

3. Summary and Conclusions

Following the success of the Huygens probe at Titan, we are looking for envisaging a similar joint effort and collaboration as per the NASA-ASI-ESA Cassini-Huygens mission, in order to explore the Ice Giant planets. At present NASA-ESA collaborative studies are in progress in order to identify potential mission configurations and a possible European contribution to a joint mission to Uranus, Neptune and its moons. One of the potential elements is an entry probe into Uranus' or Neptune's atmosphere.
On the heritage of the Huygens HASI, we are proposing a similar instrument to be flown on board of the atmospheric probe.
The scientific objectives, measurements and expected results for an Atmospheric Structure Instrument (ASI) of an entry probe at the Ice Giant planets will be presented and discussed in the framework of the opportunity for an NASA-ESA joint mission to the Ice Giants.

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We acknowledge all the support our national space agencies (ASI, CNES, FMI, UKSA) and ESA are and will ensure and grant us in order to achieve this international space endeavor.
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