INTA’s Radiometer for Uranus haze and cloud characterization. Part I: Technical Overview

V. Apéstigue¹, D. Toledo¹, P. Irwin², P. Rampou¹, A. Gonzalo¹, A. Sánchez¹, J. Martínez-Oter¹, J.-J. Jiménez¹, M. Yela¹, M. Sorribas¹, E. Sebastian¹,⁴, M. Alvarez¹, M. J. Rivas¹, D. Vázquez-Garcia de la Vega², J. Ceballos-Cáceres¹, S. Espéjo⁵, A. Ragel³, I. Arruego¹. Instituto Nacional de Técnica Aeroespacial (INTA). Torrejón de Ardoz. Madrid. Spain. ² Department of Physics, University of Oxford, Parks Rd, Oxford, OX1 3PU, UK. ³ Université de Reims Champagne-Ardenne, Reims, France. 4 Centro de Astrobiología (INTA-CSIC). ⁵ Instituto de Microelectrónica de Sevilla. Sevilla. Spain. apestiguepv@inta.es, ²

Introduction

The planetary bodies Uranus and Neptune, commonly called the Ice Giants, have yet to receive a dedicated mission. Nevertheless, in-depth analysis of these planets remains vital for gaining insight into the development and progression of our planetary system, as well as the outer systems in which ice planet systems are ubiquitous.

The present understanding of Uranus and Neptune has been derived primarily from terrestrial observations and observations conducted using space telescopes. Furthermore, a brief flyby conducted by the Voyager 2 spacecraft nearly three decades ago has contributed to our knowledge of these celestial bodies. Recently, the Decadal Survey [1] has identified a mission to Uranus as a high-priority objective for NASA’s space exploration program, in addition to its ongoing missions to Mars and Europa.

The main mission study [2] establishes the scientific priorities for an orbiter, including analyzing the planet’s bulk composition and internal structure, magnetic field, atmosphere circulation, rings, and satellite system. On the other hand, the mission includes a descent probe, which its primary mission is obtaining data on the atmospheric noble gas abundances, noble gas isotope ratios, and thermal structure using a mass spectrometer and a meteorological package.

However, a thorough investigation of the vertically distributed aerosols (hazes and clouds) and their microphysical and scattering properties is required to comprehend the thermal structure and dynamics of Uranus' atmosphere. These aerosols play a crucial role in the absorption and reflection of solar radiation, which directly influences the planet’s energy balance. In this work, we present a lightweight radiometer instrument to be included in the descent probe for studying the aerosols in the first km of the Uranus’ atmosphere.

The instrument takes its heritage from previous missions for Mars exploration [3-5], where its technology has demonstrated its endurance for extreme environments of operation, using limited resources in terms of power consumption, mass and volume footprints, and data budget. These characteristics make this instrument a valuable complementary probe’s payload for studying Uranus’ atmosphere with a high scientific return.

Instrument description

The payload is divided into two components:

- An Optical Head (OH) accommodated outside the external vessel structure with a soft shape to minimize its impact on the probe’s aerodynamic behavior. It includes up to 16 optical channels based on silicon detectors that incorporate an interference filter to select the appropriate wavelength and a Field-of-View (FoV) mask that constrains the angle of observation. This set of channels is grouped in three different orientations of observation concerning the Sun elevation. The OH also includes a Sun sensor and an obscured photodetector for calibration and evaluation of the displacement damage due to radiation. Finally, it includes two ASIC’s developed for the ExoMars [6-7] program that are capable of managing all the scientific sensors, housekeeping signals (i.e., temperature and voltage references), possible calibration strategies based on light sources, and heater control to avoid condensation. This technology has been qualified for Mars operation, compatible with extreme thermal cycling environments, with operating temperatures from -185°C to 70°C.

- A Processing Electronics (PE) based on INTA’s COMPACT (Configurable Miniaturized Processing Architecture) processor unit, which includes a microcontroller as a core of the architecture. It manages the communications with the OH through an SPI interface at 100 kbps. It implements the corresponding protocol to interchange the collected data with the probe’s OBDH using a redundant serial interface over RS-422.

References: