The Exploration of Titan and the Saturnian System

A. Coustenis
LESIA, Observatoire de Paris-Meudon, 92195 Meudon, France,
athena.coustenis@ obspm.fr

The exploration of the outer solar system and in particular of the giant planets and their environments is an on-going process with the Cassini spacecraft currently around Saturn, the Juno mission to Jupiter preparing to depart and two large future space missions planned to launch in the 2020-2025 time frame for the Jupiter system and its satellites (Europa and Ganymede) on the one hand, and the Saturnian system and Titan on the other hand [1,2]. Titan, Saturn's largest satellite, is the only other object in our Solar system to possess an extensive nitrogen atmosphere, host to an active organic chemistry, based on the interaction of N_2 with methane (CH_4). Following the Voyager flyby in 1980, Titan has been intensely studied from the ground-based large telescopes (such as the Keck or the VLT) and by artificial satellites (such as the Infrared Space Observatory and the Hubble Space Telescope) for the past three decades. Prior to Cassini-Huygens, Titan's atmospheric composition was thus known to us from the Voyager missions and also through the explorations by the ISO. Our perception of Titan had thus greatly been enhanced accordingly, but many questions remained as to the nature of the haze surrounding the satellite and the composition of the surface. The recent revelations by the Cassini-Huygens mission have managed to surprise us with many discoveries [3-8] and have yet to reveal more of the interesting aspects of the satellite.

The Cassini-Huygens mission to the Saturnian system has been an extraordinary success for the planetary community since the Saturn-Orbit-Insertion (SOI) in July 2004 and again the very successful probe descent and landing of Huygens on January 14, 2005. One of its main targets was Titan. Titan was revealed to be a complex world more like the Earth than any other: it has a dense mostly nitrogen atmosphere and active climate and meteorological cycles where the working fluid, methane, behaves under Titan conditions the way that water does on Earth. Its geology, from lakes and seas to broad river valleys and mountains, while carved in ice is, in its balance of processes, again most like Earth. Beneath this panoply of Earth-like processes an ice crust floats atop what appears to be a liquid water ocean. Titan is also rich in organic molecules—more so in its surface and atmosphere than anyplace in the solar system, including Earth [4]. These molecules were formed in the atmosphere, deposited on the surface and, in coming into contact with liquid water may undergo an aqueous chemistry that could replicate aspects of life's origins.

I will discuss our current understanding of Titan's complex environment in view of recent exploration, in particular on the atmospheric structure (temperature and composition), and the surface nature. I will show how these and other elements can give us clues as to the origin and evolution of the satellite, and how they connect to the observations of the planet and the other satellites and rings.

Future space missions to Titan can help us understand the kronian and also our Solar System as a whole. In particular, I will describe the future exploration of Titan and the Saturnian System with TSSM, a mission studied jointly by ESA and NASA in 2008 [1] and prioritized second for a launch around 2023-2025. TSSM comprises a Titan Orbiter provided by NASA that would carry two Titan *in situ* elements provided by ESA: a montgolfière and a lake-landing lander. The mission would arrive 9 years later for a 4-year duration in the Saturn system. Following delivery of the ESA *in situ* elements to Titan, the Titan Orbiter would explore the Saturn system via a 2-year tour that includes Enceladus and Titan flybys. The montgolfière would last at least 6 months at Titan and the lake lander 8-10 hours. Following the Saturn system tour, the Titan Orbiter would culminate in a ~2-year orbit around Titan.

References

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