

IAF SPACE EXPLORATION SYMPOSIUM (A3)
Solar System Exploration including Ocean Worlds (5)Author: Dr. Athena Coustenis
LESIA - Observatoire de Paris, FranceHABITABILITY POTENTIAL OF ICY MOONS AROUND GIANT PLANETS AND THEIR FUTURE
EXPLORATION WITH JUICE AND OTHER MISSIONS**Abstract**

Habitable conditions are revealed to exist in the outer solar system within the natural satellites of the giant planets, whose strong gravitational pull may produce enough energy to sufficiently heat the interiors of orbiting icy moons. Measurements from the ground but also by Voyager, Galileo and Cassini revealed the astrobiological potential of these satellites with undersurface liquid oceans, organic chemistry and energy sources [1]. Europa, Callisto and Ganymede are hiding, under their icy crust, undersurface liquid water oceans [2,3] which, in the case of Europa, may be in direct contact with a silicate mantle floor and kept warm by tidally generated heat [4]. Titan, Enceladus and Mimas, Saturn's satellites, possess active organic chemistries with seasonal variations [5], unique geological features and possibly internal liquid water oceans. Titan's rigid crust and the probable existence of a subsurface ocean create an analogy with terrestrial-type plate tectonics, at least surficial, while Enceladus' plumes find an analogue in geysers [2]. As revealed by Cassini the liquid hydrocarbon lakes [5] distributed mainly at polar latitudes on Titan are ideal isolated environments to look for biomarkers. In the Saturnian system, Mimas has also an undersurface liquid water ocean which indicates that the habitable conditions can be found very far away in the solar system. If the silicate mantles of Europa and Ganymede and the liquid sources of Titan and Enceladus are geologically active as on Earth, giving rise to the equivalent of hydrothermal systems, the simultaneous presence of water, geodynamic interactions, chemical energy sources and a diversity of key chemical elements may fulfill the basic conditions for habitability. In the solar system's neighborhood, such potential habitats can only be investigated with appropriate designed space missions, like ESA's L1 JUICE (JUperiter ICy moon Explorer) for Ganymede and Europa [3], NASA's Europa Clipper mission [4] and NASA's Dragonfly [5]. We will present recent discoveries and science goals for future space missions which may enhance our understanding of astrobiological potential throughout the solar system and beyond.

References:

Hand et al. (2020), SSR 216, 95. [2] Coustenis Encrenaz (2013), in "Life beyond Earth: the search for habitable worlds in the Universe." Cambridge Univ. Press. ISBN: 9781107026179. [3] Coustenis et al. (2021) The Bridge 51, 41. [4] Pappalardo et al. (1999), JGR 104, 24015. [5] Barnes et al. (2021), PSJ 2, 130.