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The HADES Mission Concept - Astrobiological Survey of Europa

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Introduction

The HADES Europa mission concept aims to provide a framework for an astrobiological in-depth investigation of the Jupiter moon Europa, relying on existing technologies and feasibility. This mission study proposes a system consisting of an orbiter, lander and cryobot as a platform for detailed exploration of Europa. While the orbiter will investigate the presence of a liquid ocean, characterise Europa's internal structure, and map of surface, the lander will survey the surface environment and investigate some geophysical characterisation. The lander releases a cryobot, that melts into the ice, will sample the pristine subsurface ice and is expected to provide data on organic and gaseous content and putative biosignatures. In summary, we present the scientific objectives for an astrobiological investigation of Europa, resulting in a mission concept with a detailed evaluation of scientific instrumentation, mission sequences, basic design of the spacecraft, technology needs and cost estimations. The HADES mission concept was initiated during the Alpbach Summer School in 2007 focused on astrobiology.

Context

Jupiter's icy moon Europa is one of the most promising target objects for astrobiological exploration in the solar system. Europa is suspected to host an ocean between its geodynamically active icy crust and its silicate mantle, where the main conditions for habitability may be fulfilled [1, 2, 3]. Faults and cracks in the ice of Europa indicate a history of material upwelling from below by the influence of tidal forces [4] and cryovolcanism [5], perhaps carrying liquid water to the near surface. Chaotic terrain resembling Arctic pack ice suggests regular reworking and recycling of the icy crust [3]. It is likely that the suspected liquid ocean extends down to the silicate mantle where minerals and heat from hydrothermal vents may create ambient conditions for biochemical reactions. The low number of impact craters indicates a geologically young surface, continuously remodelled by geological activity [6]. Protected from the vacuum and radiation from the space, conditions that favoured the origin and evolution of life on Earth may also exist on Europa and the production of prebiotic key compounds has already been demonstrated in laboratory experiments for a simulated Europa-like environment [7]. In the present study a new mission to Europa is proposed, that combines several strategies to create a multifunctional platform for an efficient surface and sub-surface investigation of Europa with an emphasis on habitability and the potential for life.

Sciences objectives

The HADES mission will focus on an astrobiological investigation of the Jovian moon Europa. Its primary scientific goal is to assess the habitability of Europa and to search directly for signs of complex organic chemistry that could be indicators of past or present life. The estimation of Europa's habitability will mainly be based on the presence of a putative subsurface ocean. Characterizing and understanding its structure, formation and the dynamic processes that sustain it, such as the strong geological activity triggered by Jupiter tidal forces, is of prime importance. These

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geological and gravitational characteristics of the Jovian moon have been considered to be crucial factors in the possible development of life on Europa. Thus the primary science objectives are to

1. Search for the presence of a liquid subsurface ocean
2. Characterize the depth and laminar structure of Europa's icy crust and putative subsurface ocean
3. Search for geological activity and
4. Detect and profile organic molecules present in up-welled ice at different depths.

Several strategies are combined to meet these goals. These include global mapping strategies as well as in situ analysis:

A. Precise gravity field measurement (Objective 1and 2). - B. Ice layer and ice/liquid water interface detection (Objective 1 and 2). - C. Accurate topographic data (Objective 3). - D. High resolution identification of geological features (Objective 3) - E. Characterization of the surface mineral composition (particular emphasis at sites with evidence of upwelling) (Objective 3). - F. Direct analysis of organic molecules, gaseous inclusions and biomarkers in the ice at varying depths (Objective 4).

Although an orbital study can provide valuable insights into many aspects concerning habitability, a lander would provide in-situ geophysical data and is indispensable for accurate chemical ice sample analysis. At this dose potential biomarkers or prebiotic organic molecules should be preserved. At depths of 10-25 m the radiation dose from Jupiter's magnetosphere could be low enough [8] even to preserve some intact cells of a potential subsurface biosphere. Thus, for an astrobiological survey of Europa a subsurface tool will be necessary to access pristine material.

Sciences instruments

HADES science instruments have been carefully selected to meet the science objectives as detailed in previous section. All proposed instrumentation is based on spaceflight heritage or on existing technology, thus providing high operational reliability and involving minor development effort.

Mission overview

HADES will have an expected flight duration of 6 years to reach the Jupiter system. During the cruise to Jupiter, distant imaging of the Galilean satellites and a survey of atmospheric variations of Jupiter will be carried out by the orbiter (imaging, radio science) until the Jupiter Orbit Insertion (JOI) and finally, the Europa Polar Orbit Insertion (EPOI) sequences. The HADES mission timeline follows two different phases for the study of Europa, the first one is the remote sensing of the surface from the orbit. Orbiter instruments will be active during the entire mission, to obtain a maximum spatial coverage. Due to the hard radiation environment around Jupiter, the survival time of the spacecraft around Europa is estimated to be between 60 and 90 days [9]. The second phase is the direct measurements of the ice surface and subsurface. The intended payload, lander and cryobot will consist of proven technologies adapted for the environmental conditions of this Jovian moon. Upon EPOI at Europa, the orbiter will begin to map the surface, prioritising to the pre-selected landing site. The site pre-selection, using datasets from previous missions, is based on the assumption that recent geological activity has resulted in areas where liquid water and/or warm ice has up welled and solidified on the surface [5]. The final selection will be based on the results of the geomorphology analysis from the HADES imaging and altimetry. A geophone network will monitor ice and meteoric sonic activity during lander lifetime to infer physical properties of the icy crust and determine the interface ice/liquid. This would be best achieved by a soft landing and then boring/melting to at least several metres below the surface using the cryobot. During descent into the ice, pristine samples will be acquired by drilling parallel to the surface and delivered to the GCMS and the antibody array.

References

[1] Kargel, J. S. Et al. (2000) *Icarus,*148, 226–265. [2] Pappalardo, R. T. et al. (1999) *JGR,*104, 24,015-24,055. [3] Carr, M. H. et al. (1998), *Nature*, 391, 363-365. [4] Sotin, C. et al. (2002) *GRL*, 29, 1233.[5] Fagents, S. A. et al. (2003) *JGR*, 108, 13-19. [6] Ruiz, J. et al. (2003) *Icarus*, 162, 362-373. [7] Kempe, S. et al. (2002) *Astrobiology*, 2, 123-130. [8] McKay, C. P. (2002) *Advances in Sp. Res*., 30, 1601-1605. [9] Blanc, M. et al. (2009) *Experimental Astronomy*, 23, 849-892.