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DePhine – The Deimos and Phobos Interior Explorer – A Proposal to ESA's Cosmic Vision Program

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1. Introduction

DePhine – Deimos and Phobos Interior Explorer – is a mission proposed in the context of ESA's Cosmic Vision program, for launch in 2030. The mission will explore the origin and the evolution of the two Martian satellites, by focusing on their interior structures and diversities. Are Phobos and Deimos true siblings, originating from the same source and sharing the same formation scenario? Are the satellites rubble piles or solid bodies? Do they possess hidden deposits of water ice in their interiors? After the transfer to Mars, DePhine will first enter into a quasi-satellite orbit of Deimos to carry out comprehensive surface mapping and very close flybys. The spacecraft will then enter into a resonance orbit with Phobos to perform multiple close flybys and similar remote sensing experiments as for Phobos.

2. Science Case

In spite of a long observational history, the origins of Phobos and Deimos are unknown. They may have co-accreted with the parent planet [1], or formed from Martian basin ejecta [2-5]. Alternatively, they may represent captured primitive asteroids or comets [6]. Clues on the origins of the satellites may come from comparative studies of whether Phobos and Deimos are true siblings, originate from the same source and share the same formation scenario and history. Other clues may come from investigations of the interior structures of the satellites, e.g., to resolve whether the satellites are rubble piles or solid bodies, or whether they possess hidden deposits of water ice in their interiors. The answer to the origin of Deimos and Phobos is a key to understanding the evolution of the Martian system and the workings of the solar system.

3. Measurement Goals

The mission will first focus on Deimos, to obtain the satellite's physical parameters and characteristics comparable to data already available for Phobos. In particular, we wish to determine the properties of the Deimos soil to enable comparisons with Phobos samples, assumed to be available from the Phobos sample return missions, at the launch time of DePhine [7]. In addition, the mission will address the interior structures of both satellites. We will determine shape and gravity field parameters of high degree and order to enable joint inversions, and will study the subsurfaces of Phobos and Deimos using a powerful radar. We wish to understand the spatial distribution and layering of the regolith on both satellites and map the structure of impact craters and, in particular, the Phobos grooves.

4. Science Instrumentation

The interior of the moons will be studied through several experiments. First decimetre deep layer structures and elements can be detected with the *Gamma Ray Neutron Spectrometer* (GRNS). A powerful radar instrument (SSR) will sound several tens of meters deep to detect layering or block boundaries. The bulk mass distribution will be detected through the *Gravity Radio Science Investigation of the Martian Moons* (GRIMM) experiment used to determine higher degree and order gravity field coefficients. The *Wide Angle Survey Camera* (WASC) will enable surface characterization and morphology studies, while the *Deimos Magnetometer* (DeMag) will provide information on the magnetization state of Deimos and Phobos providing indications for origin scenarios. The *eXtra Small Analyzer of Neutrals-2* (XSAN-2) and the Dust in the Martian EnviRonment (DIMER) experiments will study the environment in the vicinity of the moons.

5. Mission

The DePhine spacecraft will be inserted into Mars transfer and will initially enter a Deimos quasi-satellite orbit to carry out a comprehensive global mapping. The goal is to obtain physical parameters and remote sensing data comparable to data expected to be available for Phobos at the time of the DePhine mission to enable comparative studies. As a highlight of the mission, close flybys will be performed at low velocities, which will increase data integration times, enhance the signal strength and data resolution. 10 – 20 flyby sequences, including polar passes, will result in a dense global grid of observation tracks. The spacecraft will then change from the circular to an eccentric Mars orbit in resonance and with a pericenter close to Phobos. Benfitting from the resonance, the spacecraft will carry out multiple close flybys at low relative speeds and perform similar remote sensing as for Deimos to calibrate collected Deimos data against Phobos. A steerable antenna will allow simultaneous radio tracking and remote sensing observations by onboard instruments during flybys (which is technically not possible for Mars Express). If Ariane 6-2 and higher lift performance are available for launch (the baseline mission assumes a launch on a Soyuz Fregat), we expect to have more spacecraft resources. In particular, we may carry a small lander to be deployed on Deimos to complement the science goals of the mission.

6. Team

The mission and system design for DePhine was developed by a consortium of OHB System AG, DLR and scientists from international institutes and organisations, including: UCL, MSSL, UK; IPAG Grenoble, France; TU Dresden, Germany; INTA, Spain; IKI Moscow, Russia; IRF, Sweden; Universität zu Köln, Germany; ROB, Belgium; Johns Hopkins University, APL, USA; IMCCE, Paris, France.

References

[1] Safronov, V.S. and A.V. Vitjazev: The Origin and Early Evolution of the Terrestrial Planets, in Chemistry and Physics of Terrestrial Planets, S.K. Saxena, Editor 1986, Springer New York: New York, NY. p. 1-29.
[2] Citron, R.I., H. Genda, and S. Ida: Formation of Phobos and Deimos via a giant impact, ICARUS, 252, pp. 334-338, 2015.
[3] Craddock, R.A.: Are Phobos and Deimos the result of a giant impact?, Icarus, 211, pp. 1150-1161, 2011.
[4] Rosenblatt, P. and S. Charnoz: On the formation of the martian moons from a circum-martian accretion disk, Icarus, 221, pp. 806-815, 2012.
[5] Rosenblatt, P., S. Charnoz, K.M. Dunseath, M. Terao-Dunseath, A. Trinh, R. Hyodo, H. Genda, and S. Toupin: Accretion of Phobos and Deimos in an extended debris disc stirred by transient moons, Nature Geosci, 9(8), pp. 581-583, 2016.
[6] Burns, J.A.: Contradictory clues as to the origin of the Martian moons, Mars, 1992. p. 1283-1301.
[7] Kuramoto, K., Y. Kawakatsu, M. Fujimoto, and M.S. Team: Martian Moons Exploration (MMX) Conceptual Study Results, in Lunar and Planetary Science Conference. 2017.