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Prototype Laser Desorption/Ionization Mass Spectrometer for *in situ* Biosignature Detection on Ocean Worlds

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The presence of extinct or extant life on extraterrestrial Solar System Bodies is a high priority topic in space science. Reliable detection of signatures of life poses many challenges, including the requirement for flight-capable instrumentation, meaning robust and simple. Furthermore, instrumentation should, ideally, be capable of detecting many different types of biosignatures and not be limited to a single compound or group of molecules. Several (groups of) compounds were listed as molecules of interest in the NASA Europa Lander Report, including amino acids, lipids, and polycyclic aromatic hydrocarbons (PAHs)[1]. Moreover, high sensitivity is required to detect biosignatures with trace abundances, while, simultaneously, highly abundant compounds should not be excluded, meaning a broad dynamic range is essential.

The search for presence of life is aimed towards several Solar System bodies. Two new astrobiological targets, Enceladus and Europa, were recently uncovered as an outcome of the Galileo and Cassini-Huygens missions [2]. They revealed the presence of oceans under the ice shells. Both “ocean worlds” are of high interest for detection of signatures of life, mainly because of putative presence of all ingredients required to form life (as we know it). If life is indeed present on these bodies, its biosignatures could be preserved in near surface ice, where they are protected from the harsh environment.

ORIGIN (ORganics Information Gathering INstrument) is a novel prototype laser desorption/ionization mass spectrometer (LDMS). ORIGIN was designed for *in situ* detection of biomolecules for future space exploration missions, and subsequently constructed at the University of Bern, Switzerland [3]. The design is compact and simplistic, making it a robust and lightweight system, which meets the requirements of space instrumentation. The current setup of ORIGIN is comprised of a nanosecond pulsed laser system for desorption of analytes, and a miniature reflectron-type time-of-flight mass analyzer (160 mm x Ø 60 mm)[4]. Positive ions are generated by laser desorption and separated in the mass analyzer based on their mass-to-charge ratio (TOF principle), resulting in a single mass spectrum for each laser shot.

The capabilities of ORIGIN were recently demonstrated by measurements of amino acids standards and now extended to PAHs and lipids [3,5,6]. Studies were conducted to investigate the limit of detection, optimal laser desorption conditions, and influence of the sample substrate. In our contribution, we will discuss the setup and measurement procedures, and show results of several studies regarding the performance of ORIGIN, specifically regarding detection of several potential biosignature targets. The implications of our results will be discussed, with a focus on the suitability of the presented technique for future space missions to explore Ocean Worlds in the search for signatures of life.

References:
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