Physics & Astronomy PhD Project Proposal

Project Title: Instrumentation studies for future astrobiology and planetary exploration missions

Groups: Planetary

Supervision Team:

- 1st Supervisor: Dr Melissa McHugh (mm875@le.ac.uk)
- 2nd Supervisor: Prof Ian Hutchinson (ibh1@le.ac.uk)
- 3rd Supervisor: Dr Hannah Lerman (hnl4@le.ac.uk)

Three Key Points

- The design and development of novel spectroscopy instrumentation for missions with astrobiology science goals.
- Assessing an instrument's capability of measuring habitability (i.e. through the detection of CHNOPS elements, mineral hydration levels and metabolic energy sources)
- Assessment of the performance of analytical instrumentation in extreme environments as part of future mission preparations.

Project Description:

This project centres around the development of novel spectroscopy instrumentation for future space missions, focusing on missions to astrobiology targets such as Mars, Europa and Enceladus, in order to assess potential habitability. Habitable environments require three essential components to accommodate life: CHNOPS elements (but also monovalent and divalent ions); an energy source, usually in the form of a redox couple; and liquid water. Consequently, the likelihood that an environment could support life processes can be determined by assessing redox conditions, the nature/existence of water-mineral interaction processes, and biogenic mineralization (which can all be measured with using analytical techniques such as Raman spectroscopy).

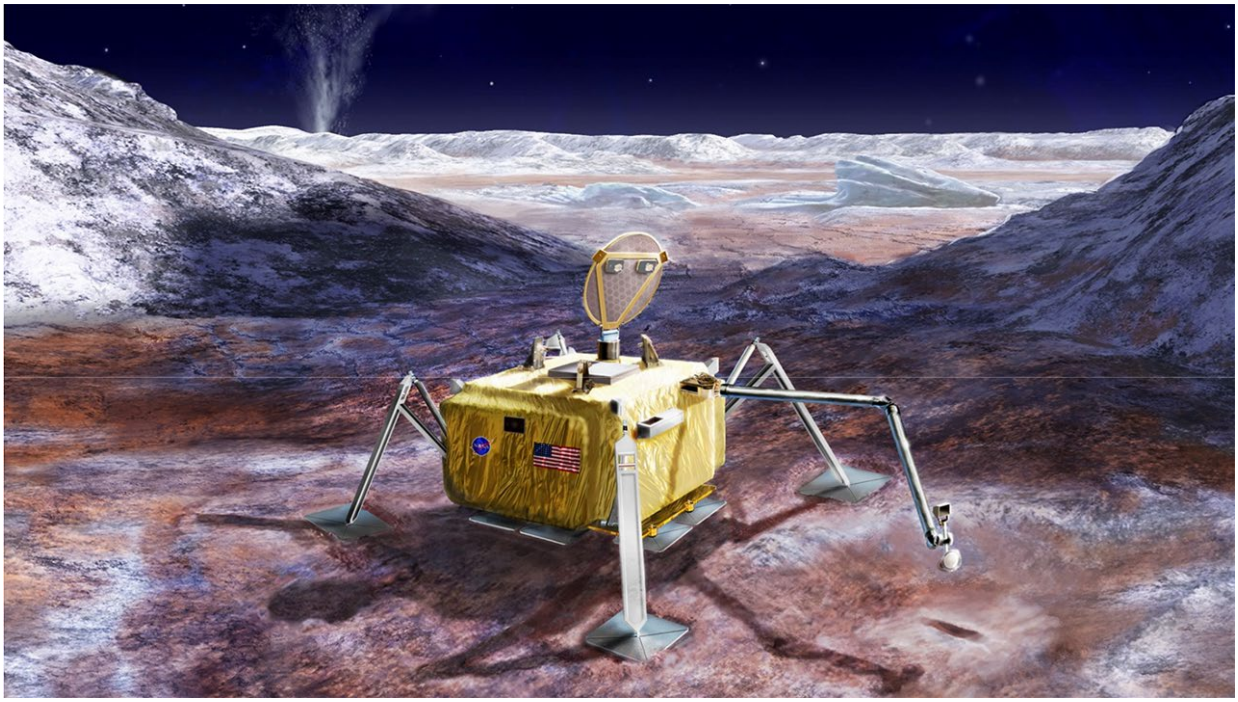
As exploration missions become more advanced, innovative technologies and measurement techniques become critical in order to meet far reaching science goals. The proposed work will involve developing specialist analytical instrumentation (stand-off measurements, hyperspectral imaging and combined techniques, for example) for lander or rover platforms, that will be capable of detecting signs of habitability. The work will focus of adapting traditional instrument configurations for deployment in extreme environments, with emphasis on testing in field locations and with planetary analogue material.

The supervisory team are members of ESA's ExoMars Raman Laser Spectrometer group and are involved in two instrument development activities that have followed on from the work completed for the ExoMars programme: the design of a handheld Raman-XRF instrument for use by an astronaut on the moon (funded through the ESA PANGAEA programme), and the integration of spare RLS flight subsystems on the ispace HAKUTO-R rover mission, due for launch in 2026. This study will build upon these state-of-the-art systems (the student will have access to flight spare instrumentation) in order to develop the next generation of instrumentation for planetary surface exploration.

Further Reading:

- *F. Rull, S. Maurice, I. Hutchinson, et al., "The Raman Laser Spectrometer for the ExoMars Rover Mission to Mars", 2017, Astrobiology 17*
- Edwards, H. G., Hutchinson, I. B., Ingley, R., & Jehlička, J. (2014). Biomarkers and their Raman spectroscopic signatures: a spectral challenge for analytical astrobiology. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 372(2030), 20140193.
- Shi, Erbin, Alian Wang, and Zongcheng Ling. "MIR, VNIR, NIR, and Raman spectra of magnesium chlorides with six hydration degrees: Implication for Mars and Europa." Journal of Raman Spectroscopy 51.9 (2020): 1589-1602.

Images/Graphics:



NASA's Europa Lander: As a follow on from Europa Clipper, the Europa Lander would aim to perform an in-situ search for signs of life on the ocean world.

Application advice: Please see web page

https://le.ac.uk/study/research-degrees/funded-opportunities/stfc