OU PhD Project Proposal Form – 2020 entry

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<th>Project Title</th>
<th>OU19: Detecting potential bio-signatures for Enceladus</th>
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<td>Key words</td>
<td>Icy moons, microbiology, biomarker</td>
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| Supervisory team (including institution & email address) | Karen Olsson-Francis, Vic Pearson and Susanne Schwenzer  
karen.olsson-francis@open.ac.uk **External Collaborators:** Frank Postberg and Jon Hillier (Freie Universität Berlin), Ralf Srama (Universität Stuttgart), and Ruth-Sophie Taubner (Universität Wien) |
| Is the PhD suitable for part time study? | Yes ☐ No ☒ |

**Project Highlights:**

- Novel simulation experiments investigating biosignature modification in Enceladus’ ocean, using state-of-the-art facilities.
- Pioneering hypervelocity dust experiments that can be applied to understanding data returned from the Cassini mission.
- An interdisciplinary training programme with elements of geochemistry, microbiology, and physics.

**Overview:**

The plumes emitted from the South Polar Region of Enceladus have been investigated extensively by the Cassini mission. Returned data implies they are fed by a global ocean situated below an ice shell atop a porous silicate interior.

Further information regarding the sub-surface ocean has been obtained from Cassini’s Ion and Neutral Mass Spectrometer (INMS) instrument, which detected water, ammonia, molecular hydrogen, simple organic compounds, and potentially sulfur; whilst higher molecular weight organic molecules, salts, biologically-available nitrogen, and nanosilica particles have been detected in plume ice grains by the Cosmic Dust Analyzer (CDA). Based on these observations, it is predicted that all of the key elements required for life, i.e., C, H, N, O, P, and S, are expected to be present in the sub-surface ocean since they have either been detected in the plumes or are expected to be present owing to water-rock interaction at the ocean floor. Hence, Enceladus is of interest from an astrobiological perspective.

Although the sub-surface ocean may be deemed habitable, finding evidence of life with instruments onboard a spacecraft is dependent on detecting the bio-signatures that are uniquely produced by microbial life. The aim of this studentship is to determine the feasibility of detecting these unique biosignatures in the plumes using a combination of simulation facilities at the Open University, Freie Universität Berlin, and the University of Stuttgart. The project will: 1) identify likely biosignatures generated in the sub-surface ocean, based on the results of simulation experiments; 2) determine the appearance of these biosignatures after plume emission via mass spectrometric analysis from a spacecraft.
Figure 1: Illustration of the interior of Enceladus showing the global ocean. Credit NASA/JPL-Caltech.

Methodology:
To investigate the feasibility of detecting bio-signatures from Enceladus the following experiments will be conducted and combined with data from Cassini:

1) Drawing on the results of previous simulations and modelling, subject analogue microorganisms to a simulated Enceladus sub-surface ocean environment;
2) Determine the organic biosignatures these organisms may generate and investigate their processing within the oceanic environment;
3) Use suitable laboratory techniques to produce mass spectra from the biosignatures, analogous to those produced by hypervelocity impacts onto instruments on a spacecraft;
4) Analyse laboratory mass spectra, corresponding to a range of particle compositions and encounter conditions, to predict the mass spectral appearance of likely biosignatures within grains emitted from cryovolcanic plumes into space.

Training and skills:
The student will gain training in specific techniques in organic geochemistry, laboratory experimentation, and microbiology. The student will carry out an extensive review of possible conditions at Enceladus’ hydrothermal sites and the ocean. The Open University has comprehensive laboratory facilities for all required analyses.

The student will benefit from a diverse training programme, ranging from skills that support their PhD studies, e.g., writing skills, time management, presentation skills, research skills and thesis writing, and skills that prepare them for the future after graduation, e.g., CV writing and networking, including making active contact with industry and academic partners.
Partners and collaboration:
The groups at Freie Universität Berlin and the University of Stuttgart are world-leading in the simulation and analysis of impact ionisation mass spectra, with strong links to not only the Cassini Cosmic Dust Analyzer, but also future missions to, e.g., Europa. The student will receive training in the analysis of time of flight mass spectra, as well as in the laboratory simulation of hypervelocity impacts both at Freie Universität Berlin and/or the Universität Stuttgart in Germany.

Possible timeline:

Year 1: Perform a literature review and set up laboratory-based sub-surface ocean simulation experiments using an analogue microbial community. Infer suitable samples for further simulation experiments.

Year 2: Set up and run ocean simulation experiments. Submit manuscript regarding production of biosignatures in the sub-surface ocean of Enceladus. Present results at a national conference. Prepare samples for simulated plume hypervelocity sampling experiments and help execute these experiments during visits to Berlin and Stuttgart, respectively.

Year 3: Complete simulation experiments. Submit manuscript regarding survival of bio-signatures in simulated plume experiment. Write and submit thesis. Present data at an international conference.

Further reading:


Further details:

Students should have a strong background in organic chemistry/geochemistry, or a laboratory-based discipline. The student will join a research team at the Open University that has extensive experience in running laboratory simulation experiments and will visit and collaborate with the groups at Freie Universität Berlin and Universität Stuttgart, in simulating and analysing hypervelocity impact ionisation mass spectra.

The successful student will join a well-established team, AstrobiologyOU (here) and a vibrant postgraduate community at the Open University.

Please contact Dr Karen Olsson-Francis (karen.olsson-francis@open.ac.uk) for further information.
Applications should include:

- a cover letter outlining why the project is of interest and how their skills match those required,
- an academic CV containing contact details of three academic references
- and an Open University application form, downloadable from (UK/EU students):  [http://www.open.ac.uk/students/research/system/files/documents/Application%20form%20-%20uk-eu_0.docx](http://www.open.ac.uk/students/research/system/files/documents/Application%20form%20-%20uk-eu_0.docx)
- (International Students):  [http://www.open.ac.uk/students/research/system/files/documents/Application%20Form%20-%20Overseas_0_0.docx](http://www.open.ac.uk/students/research/system/files/documents/Application%20Form%20-%20Overseas_0_0.docx)

Applications should be sent to [STEM-EEES-PHD@open.ac.uk](mailto:STEM-EEES-PHD@open.ac.uk) by 12pm (noon) on Friday 7th February 2020.