The feasibility of *in situ* VOC analysis on icy bodies

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To date, knowledge of the composition of the ices on bodies such as Enceladus and Europa are limited to remote sensing techniques carried out by orbiting spacecraft; no ground-truth *in situ* measurement have yet been made. The current level of interest in these bodies is driven, in part, by their potential habitability. Of particular interest are volatile organics, of which CO, CO$_2$, CH$_4$, NH$_3$, C$_2$H$_2$, etc. have been detected remotely in the plumes Enceladus (Postberg et al., 2011) and CO, CO$_2$, NH$_3$ and ‘light’ organics detected spectroscopically on the ice surface (Brown et al., 2006). A question remains as to whether the organics detected are the result of photochemistry or are sourced from upwelling from the sub-surface ocean environment. This is important in order to understand carbon cycling within the Solar System, particularly in light of recent results from Cassini, that may indicate a complex organic chemistry on the Enceladus ocean floor (Postberg et al., 2018).

The interest in these icy bodies means that opportunities are likely to arise in the future for *in situ* analysis performed by landed spacecraft elements. Ideally, such instruments will not only take surface measurements, but will also be able to access the sub-surface, shielded by space weathering.

This studentship intends to simulate the icy conditions likely in the surface and sub-surface, establish extraction protocols to enable those ices to be analysed, and determine the feasibility of utilising state-of-the-art miniature mass spectrometry to characterise the composition of those ices *in situ*.

The studentship would initially involve the creation of a series of ice simulants of known compositions, based on the results from orbiting spacecraft, the results of our existing simulations and modelling of icy moon environments, and the results from surface measurements from comet 67P/Churyumov-Gerasimenko obtained by the Ptolemy mass spectrometer (Todd et al., 2006 and Wright et al., 2015). The student would be supported to design and commission a cryogenic vacuum system in which ices can be grown under varying environmental conditions. A similar system has been developed at The Open University to simulate lunar regolith in polar shadowed regions, where there could be high concentrations of water ice; however, the existing system requires modification and addition of a bespoke manifold through which different mixtures of volatile organic compounds (VOCs) (e.g., CO, CO$_2$, CH$_4$) can be admitted to create ices of varying composition within a water ice matrix.

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The student will then establish experimental protocols for the extraction of the VOCs from the ice matrices (e.g., heating and headspace sampling, volatile extraction through membranes from ice melt and volatilisation) in order to compare that with the input compositions. The comparison will be undertaken by building on the heritage of Ptolemy and LUVMI (Urbina et al., 2017) mass spectrometer instruments. This will allow the evaluation of the viability of using existing space flight designs of mass spectrometers, and the development of protocols and the optimisation of analysis techniques for the anticipated volatiles. This studentship allows the preliminary evaluation of an in situ VOC analytical system for icy bodies in preparation for future mission proposals.

References:

5. Wright et al., 2015. CHO-bearing organic compounds at the surface of 67P/Churyumov-Gerasimenko revealed by Ptolemy. Science, 349(6247). Available at: http://science.sciencemag.org/content/349/6247/aab0673
6. Urbina et al., 2017. LUVMI: an innovative payload for the sampling of volatiles at the Lunar poles. IAC 2017, Adelaide Australia. Available at: https://www.researchgate.net/publication/321036048_LUVMI_an_innovative_payload_for_the_sampling_of_volatiles_at_the_Lunar_poles

Qualifications required:

This studentship would be best suited to a student with a masters or first class degree in chemistry or physics, with an interest in space-flight applications and opportunities.