UNIVERSITY OF LEICESTER

X-ray optic development for studying moons in the outer solar system

• Novel X-ray optic development for future space missions in collaboration with the manufacturers • Modelling and analysis of the requirements and performance of an X-ray optic at the icy moons • Measuring the X-ray response of rocks and ices to electron impact to provide experimental validation	**Level**	PhD
	First Supervisor	Dr Charly Feldman chf7@le.ac.uk
	Second Supervisor	Dr Adrian Martindale
	Application Closing Date	20th January 2023
	PhD Start date	September 2023

Project Details:

In both ESA's Voyage 2050 (https://tinyurl.com/mryev7tn) and NASA's Planetary Science Decadal Survey 2023-2032 (https://www.nationalacademies.org/our-work/planetary-science-and-astrobiology-decadal-survey-2023-2032#sectionPublications), there was strong emphasis on missions to the outer planets, in particular understanding the interactions between the larger planets and their moons, and measuring the compositions of the surfaces of these moons. An X-ray fluorescence spectrometer allows us to address both of these questions; placed into orbit around an icy moon, it would be able to measure the composition of the surface by observing characteristic X-ray emission (and thick-target Bremsstrahlung) from the moon as it is bombarded by energetic particles within the host planet's magnetosphere. X-ray fluorescence spectrometers have been successfully used to study the Moon and Mercury, but a mission such as this to a giant planet system represents a completely new and largely unexplored target to study.

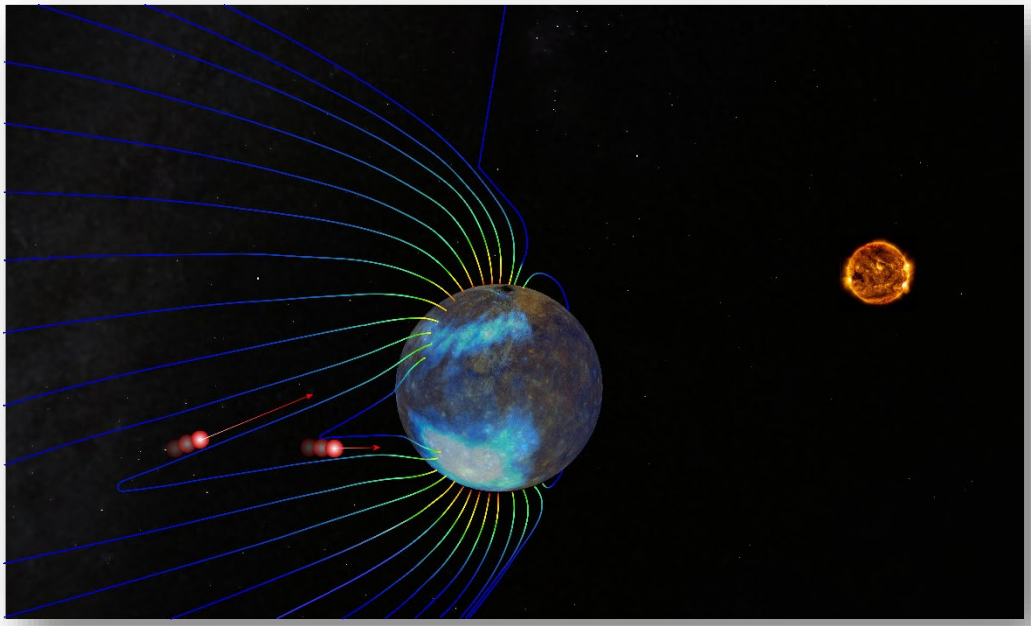
By far the most efficient way of creating such an instrument is a lobster eye telescope formed from lightweight Micro Pore Optics (MPOs). The University of Leicester is a world leader in the development and deployment of MPO-based instruments, including MIXS on board BepiColombo and instruments on the forthcoming SMILE and SVOM missions. However, in order to achieve the required scientific goals in the hostile conditions of a giant planet magnetosphere, the current best performance of MPOs needs to be improved.

This PhD is highly experimental, leveraging the Vertical Test Facility and Electron Impact Facility, two new facilities at the University of Leicester, to establish the expected signal from the surfaces of icy moons, generate a list of scientific objectives for an MPO based instrument on an orbiter and demonstrate how the optic technology fulfils these requirements in terms of collecting area and spatial resolution. The student will develop the required metrology techniques (in collaboration with the MPO manufacturer – Photonis, https://www.photonis.com/) that will enable the factor of two resolution improvement that is known to be needed for the MPOs, and produce publishable research on the interaction of electron beams with laboratory analogues of the moons in the outer solar system. They will show how observing X-rays remotely would enable a spacecraft to make measurements of the surface composition, the intensity and dynamics of the falling charged particle populations in the moon's environment, and the complex processes relating them to one another.

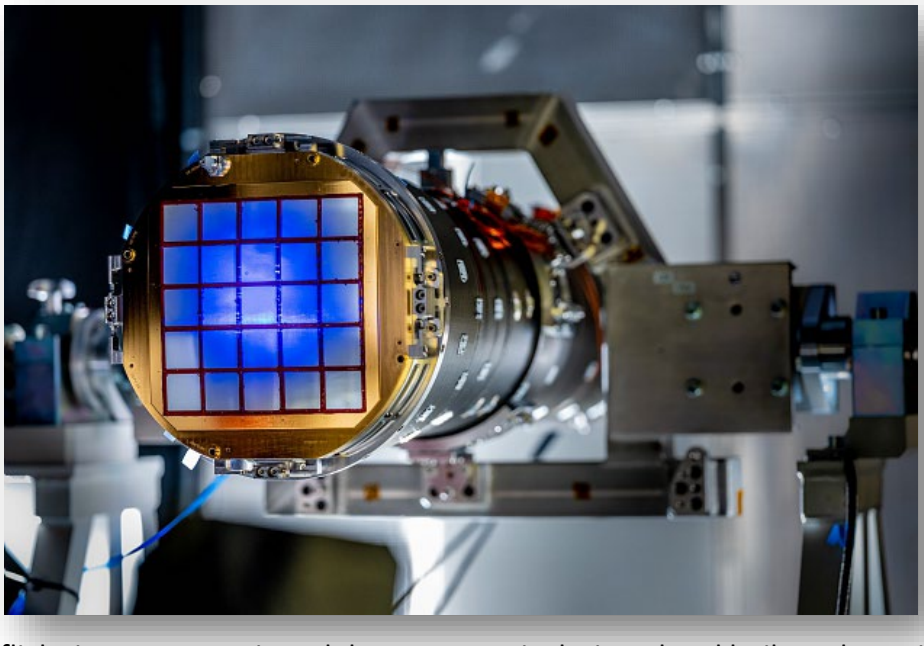
The goal of the PhD is to come up with a credible instrument for an outer solar system mission. Day-to-day the student will be; producing suitable surface analogues for a range of icy moons; using the electron impact facility to identify X-ray response to electron illumination for these analogues across different electron energies; developing modelling to accurately simulate the emission from the moon's surface and; collaborating with Photonis, develop

and improve the production of the MPOs using experiments in the VTF and further modelling. This will lead to an optic that can deliver the science goals and demonstrate the ability to measure the modelled spectras.

Scientifically, the project is timely, allowing us to capitalise on the recent Voyage 2050 reports and NASA's Planetary Science Decadal Survey and the ongoing Heliophysics Decadal Survey, to prepare a justified scientific case for X-ray observations in the outer solar system - this PhD work needs to be started within the next year. Photonis are building their own VTF facility within the next 15 months and after training, the student would be ready to work directly with Photonis on process development.



Precipitation of electrons at Mercury drives X-ray emissions from the surface in aurora-like zones. A similar process will occur on the surfaces of icy moons. (S. Lindsay, UoL)



The SVOM MXT flight instrument using a lobster eye optic designed and built at the University of Leicester. (© CNES/DE PRADA Thierry, 2021)

References:

- Feldman, C. et al., "The development of the THESEUS SXI optics," Proc. SPIE 11444, Space Telescopes and Instrumentation 2020: Ultraviolet to Gamma Ray, 114448X (13 December 2020). https://doi.org/10.1117/12.2562141
- Bunce, E.J., Martindale, A., Lindsay, S. et al. "The BepiColombo Mercury Imaging X-Ray Spectrometer: Science Goals, Instrument Performance and Operations," Space Sci Rev 216, 126 (2020). https://doi.org/10.1007/s11214-020-00750-2
- Lindsay, S., James, M., Bunce, E. et al. "MESSENGER X-ray observations of magnetosphere–surface interaction on the nightside of Mercury," Planetary and Space Science 125, 72-79 (2016). https://doi.org/10.1016/j.pss.2016.03.005..

How to apply:

Include with your application:-

- CV
- Degree Certificates and Transcripts
- Details of any study currently being undertaken
- Personal statement
- Enter the supervisor's name and project title in the Proposal Section (no proposal required)
- Enter contact details of two academic referees in the boxes provided or upload reference letters if already obtained.
- Evidence of English language if applicable.
- In the funding section include: Ref: Feldman - UKRI (STFC)

The University of Leicester School of Physics and Astronomy has advertised a number of PhD opportunities. If you are applying for more than one University of Leicester project, please indicate if this is your first, second or third choice, in your application.

Further information on how to apply and funding can be found here