**University of Leicester Future 100 PhD Scholarship**

**Project Reference: RI-SPACE-Martindale**

**Section 1 – *Supervisor Information***

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| **First Supervisor**  | Dr Adrian Martindale |
| **School/Department** | Physics and Astronomy |
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| **Proposed Second Supervisor** | Dr Tiffany Barry |
| **Additional Supervisor** | Dr Simon Lindsay (ECR) Physics and Astronomy |

**Section 2 – *Project Information***

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| **Project Title** | **Mercury’s surface composition – from global to local scales** |
| **Project Highlights:** | 1. | Develop skills that will place the researcher at the forefront of processing data from the Mercury Imaging X-ray spectrometer in time for the first data to be returned from Mercury in 2025+ |
| 2. | Enhanced experimental knowledge in x-ray spectra collection and calibration to physical analogues |
| 3. | Prepare for BepiColombo science data by devising experiments and data analysis methods to discriminate competing hypotheses for the observed features on Mercury’s surface |
| **Project Overview**  |
| This multidisciplinary project will provide the successful student with a unique training opportunity, integrating them with the University of Leicester (UoL) - BepiColombo team, and international working groups led by the European Space Agency and Japan Aerospace Exploration Agency. The post-graduate researcher (PGR) will help secure Leicester’s leadership of the science return from the Mercury Imaging X-ray spectrometer (MIXS) by doing essential work to prepare for when it commences mapping in 2026. They will be in a very strong position to continue this research as a PDRA. BepiColombo is Europe’s first mission to the planet Mercury and carries UoL’s MIXS instrument (Bunce et al. 2020 – DOI: 10.1007/s11214-020-00750-2), an imaging X-ray fluorescence spectrometer that will map the elemental abundances in Mercury’s surface from orbit. MIXS is a unique instrument, of a type never before flown to another planet, offering new opportunities for scientific measurements. Mercury has unique features and as a likely ‘planetary embryo’ can provide crucial insights about the formation and evolution of the terrestrial planets. NASA’s 2011-2015 MESSENGER mission provides the best current knowledge of Mercury’s surface, showing a planet with heterogeneous geochemical terranes that correlate well with surface geology - such as the northern volcanic plains and inter-crater plains. But, MESSENGER also found unexpected features like the High Magnesium Terrane (HMT); recent work at UoL (Hall et al. 2021 – DOI: 10.1029/2021JE006839) suggests a link between these and large impacts excavating deep crustal material. During this project, the student will investigate how MIXS data can resolve competing hypotheses for such features on Mercury.The experimental work will use our MIXS ground reference facility (an experimental chamber funded by UKSA) and facilities in GGE to fully characterise Mercury surface analogues. The results will inform how MIXS data will be used to make critical links between geochemical data and optical images e.g. impact structures, volcanic features and the scientifically important “hollows” features believed to have formed from loss of volatiles. By doing so, it will provide a roadmap for a series of major contributions to the literature based on MIXS data and foster collaboration across the University and with international teams. |
| **Methodology**  |
| The PGR will:* study the X-ray fluorescence process to determine the composition of surface rocks/regolith remotely (chapter 2);
* simulate MIXS observations using existing X-ray fluorescence models, spacecraft ephemeris predictions and historical solar flux data in order to show how MIXS will solve open questions about Mercury’s surface (chapter 3);
* experimentally test the sensitivity of MIXS across a range of elements, and investigate uncertainties in the abundance measurements (e.g. X-ray background, counting statistics or from modelling artifacts). This work will target important species identified by MESSENGER (e.g. S, Na and K) which Nittler et al. 2018 (doi:10.1017/9781316650684.003) show are relatively enriched compared to expectations (chapter 4).
* bring together simulations of MIXS observations with the results of the experimental work and observations reported from MESSENGER data in order to optimise MIXS data analysis methods and identify specific targets to observe to help resolve competing hypotheses in Mercury’s geochemistry (chapter 5).

**References**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> Hall, G. P., Martindale, A., Bridges, J. C., Nittler, L. R., & Bunce, E. J. (2021). The distribution of peak-ring basins on Mercury and their correlation with the high-Mg/Si terrane. Journal of Geophysical Research: Planets, 126, e2021JE006839. <https://doi.org/10.1029/2021JE006839> Rothery, D.A., Massironi, M., Alemanno, G. *et al.* Rationale for BepiColombo Studies of Mercury’s Surface and Composition. *Space Sci Rev* **216,**66 (2020). <https://doi.org/10.1007/s11214-020-00694-7> Vye-Brown, C., **Barry, T.L.,** & Self, S., 2018. Revealing emplacement dynamics of a simple flood basalt eruption unit using systematic compositional heterogeneities. GSA Spec., [doi.org/10.1130/2018.2538](http://doi.org/10.1130/2018.2538)Williams, R.W., Branney, M.J., & **Barry, T.L.,** 2014. Temporal and spatial evolution of a waxing then waning catastrophic density current revealed by chemical mapping. *Geology*, 42, 107-110.  |