

# Physics & Astronomy PhD Project Proposal

**Project Title:** Magnetosphere-surface Interactions at Mercury

**Project reference:** STFC - Bunce

**Groups:** Planetary/SPI

**Supervision Team:**

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## Three Key Points

- Understand complex magnetosphere-surface interactions by studying Mercury's nightside surface X-ray emission
- Continue investigation of MESSENGER's nightside X-ray events by delving into case studies of interest
- Study the first data from the ESA/JAXA BepiColombo mission, and from the Leicester-led MIXS instrument

## Project Description

BepiColombo is the first interplanetary dual-spacecraft mission, comprising the ESA Mercury Planetary Orbiter (MPO) focusing on the planet, and JAXA Mercury Magnetospheric Orbiter (MMO) dedicated to the space environment. The main science mission for BepiColombo begins in Spring 2027, and will greatly enhance the results obtained by NASA MESSENGER (2011-2015).

The Mercury Imaging X-ray Spectrometer (MIXS) is the only UK instrument on the BepiColombo payload, designed and built at Leicester. By observing fluorescence X-rays generated when solar X-ray photons and charged particles interact with the surface regolith, MIXS will be able to measure the atomic composition of Mercury's surface on the sunlit side of the planet. When energetic electrons hit Mercury's surface (Image 1), they also generate characteristic X-rays from the surface. Consequently, MIXS will allow us to determine the complex interaction between Mercury and its space environment through X-ray observations (particularly) on the nightside of Mercury.

The project involves investigation of previous MESSENGER measurements, including X-ray fluorescence spectra, magnetic field, and energetic particles from Mercury's magnetosphere. The student will also analyse the FIRST data from BepiColombo mission, working alongside the MIXS team at Leicester. This will be a substantial component of the PhD project, providing new insights on magnetosphere-surface interaction. This will be a very exciting time to be part of this new mission!

An additional element of the project could involve in-house laboratory experiments to investigate the production of fluorescent X-ray emission from various analogues of Mercury's surface under bombardment from controlled electron sources.

There are three main aims:

We will focus on particle and magnetic field measurements taken by MESSENGER in regions magnetically conjugate to previous observations of particle induced X-ray emission (PIXE), in order to understand the particle populations responsible for the X-ray emissions.

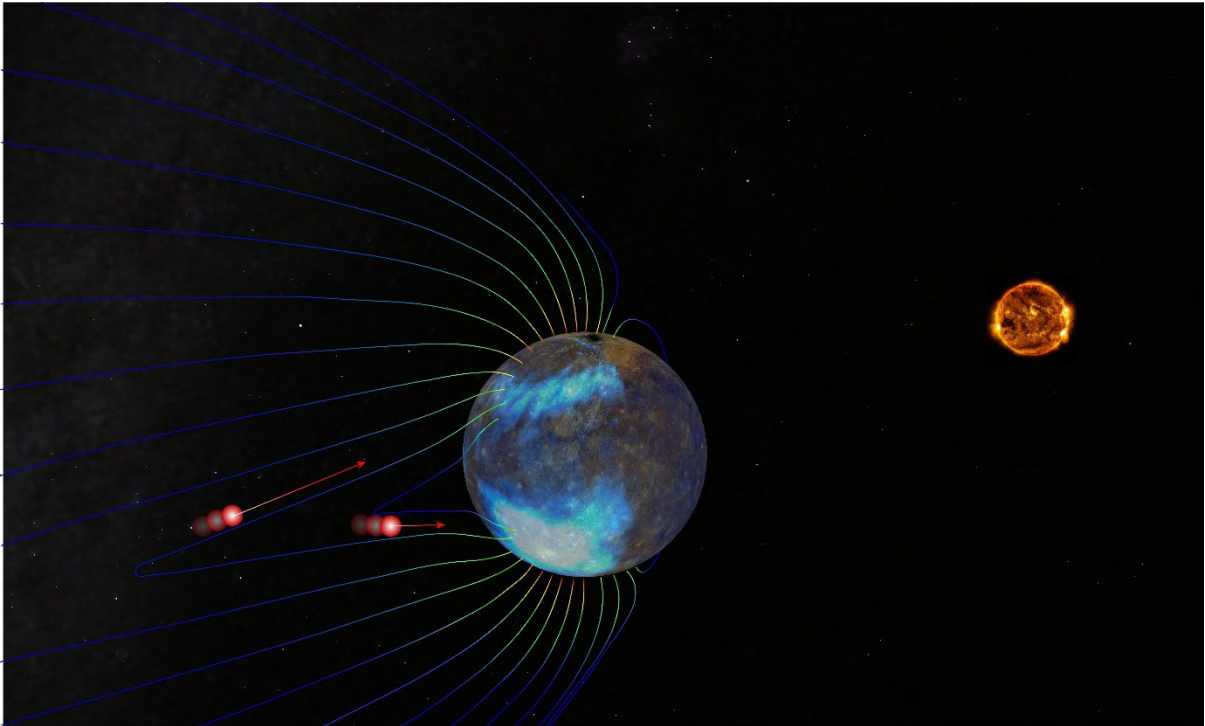
We will undertake an analysis of how PIXE events measured through the lifetime of the MESSENGER mission relate to the open-closed field line boundary at Mercury.

We will receive and analyse the FIRST data from the ESA/JAXA BepiColombo mission and this project will focus on the interpretation of the nightside observations of X-ray fluorescence produced by the magnetosphere-surface interaction.

#### Further Reading:

- Bunce et al. [2020], MIXS Instrument Paper <https://doi.org/ezproxy4.lib.le.ac.uk/10.1007/s11214-020-00750-2>
- Lindsay et al. [2016], Nightside X-ray Emissions, <https://doi.org/10.1016/j.pss.2016.03.005>
- Winslow et al. [2017], ICME Catalogue, <https://doi.org/10.1002/2016JA023548>
- James et al. [2017], Upstream Solar Wind at Mercury, <https://doi.org/10.1002/2017JA024435>

**Application advice: Please see web page**  
<https://le.ac.uk/study/research-degrees/funded-opportunities/stfc>



A schematic of electrons being accelerated in Mercury's nightside magnetosphere and precipitating onto the surface to form the bands of "auroral" X-ray fluorescence measured by MESSENGER, which are associated with the northern and southern open-closed field line boundaries