The dynamics of Earth's magnetopause and their space weather impacts

PhD project
Space, Plasma & Climate Physics
October 2026 start, full-time

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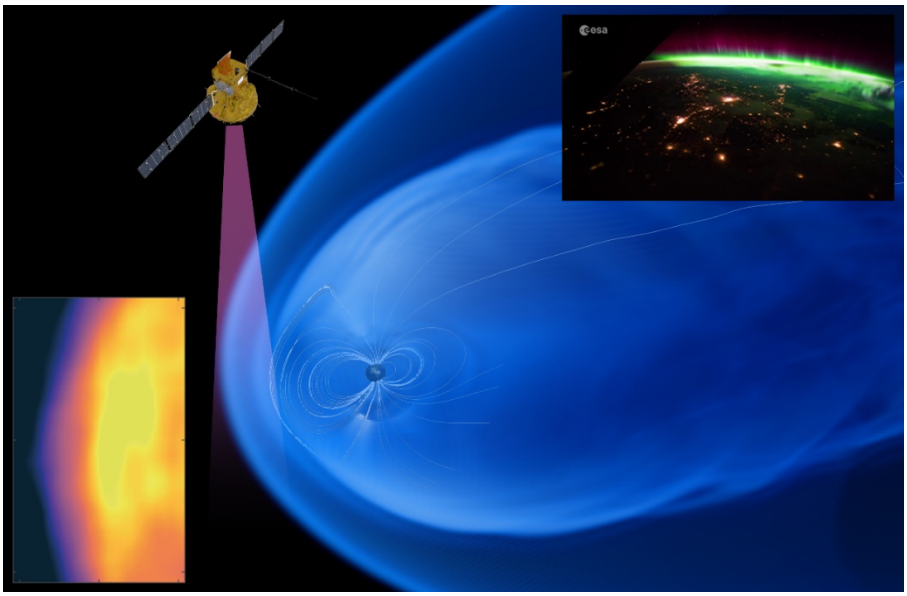

This PhD project will probe the coupling and interplay between the solar wind and magnetosphere at its interface, the magnetopause, in new ways to understand not only the fundamental space plasma interactions but also elucidate how these impact upon our global space environment leading to space weather effects that can affect our everyday lives and society.

Across the **plasma universe** different systems (e.g. solar corona, planetary magnetospheres, heliosphere, stellar accretion discs) are bounded by **sharp discontinuities**. How these boundaries respond to continual external forcing by filtering, accumulating, and guiding disturbances plays a vital role in mediating mass, momentum, and energy transfer to these systems. While the most-accessible large-scale plasma boundary is **Earth's magnetopause**, to date it has only been observed when encountered by *in situ* spacecraft. Deciphering the different dynamical boundary processes, which may occur simultaneously, however, requires near-continual large-scale monitoring of the magnetopause location.

The **ESA-CAS SMILE mission** launching early 2026 will image the dayside magnetosphere for the first time in soft X-rays from solar wind charge exchange. Since X-ray emissions are expected to peak at the magnetopause, SMILE offers the possibility of remote sensing magnetopause dynamics for the first time. This exciting new capability offers many possible opportunities in determining the large-scale response of the first link in the geospace processing chain that ultimately leads to space weather.

You will work in the context of international collaborations and the wider multi-national mission and instrument teams. Depending on your interests and skills, there will be opportunities to be involved with:

- Processing and analysing cutting-edge **SMILE remote sensing** soft X-ray data to track the magnetopause's motion for the first time
- Undertaking **global simulations** of the solar wind – magnetosphere interaction using the Gorgon magnetohydrodynamic code developed at Imperial (shown above) for interpreting of SMILE observations
- Leveraging **constellations of *in situ* spacecraft** observing conditions within the solar wind and magnetosphere, linking these to one another and SMILE observations
- Analysing **globally distributed ground-based measurements** of auroral, ionospheric, and geomagnetic processes to determine how space weather effects arise from the dynamics in space
- Developing **magnetohydrodynamic theory** and numerical models underpinning these observations

This project is highly centred on data analysis, computer programming, and data visualisation. Experience with these will be vital. It will also leverage advanced interdisciplinary signal processing and machine learning methods, which it would be an advantage for you to have some familiarity with. Knowledge of basic plasma or space physics would also help, but is not necessarily required upon application.

For more information, please contact Dr Martin Archer (m.archer10@imperial.ac.uk)