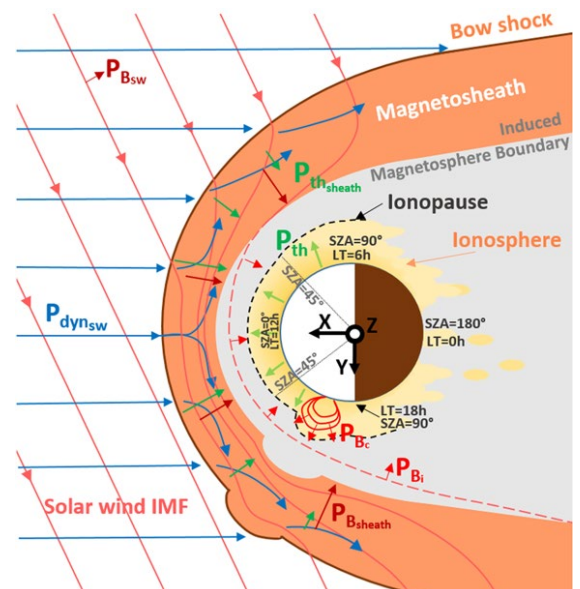


# The role of crustal magnetic fields on Mars' ionospheric dynamics

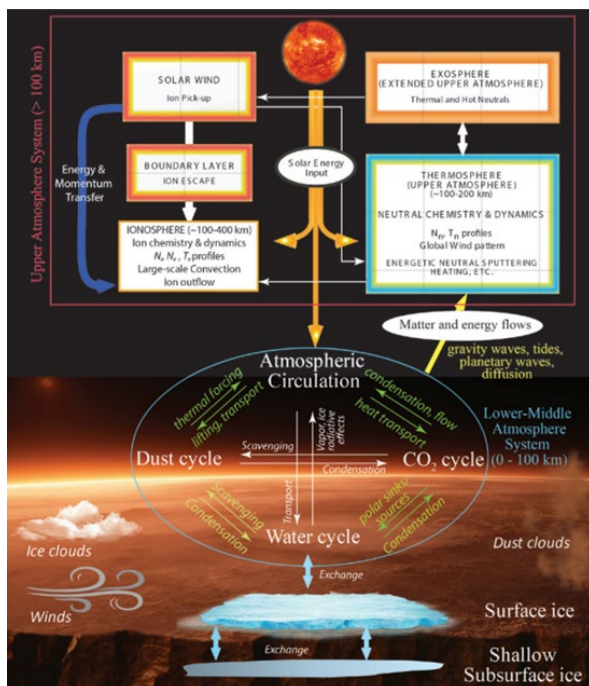
<ul style="list-style-type: none"> <li>Multi-spacecraft data analysis, including MAVEN, Mars Express and Mars Reconnaissance Orbiter missions</li> <li>Long and short term ionospheric dynamics over crustal field regions</li> <li>Crustal field guidance of solar wind particle distribution over the ionosphere</li> </ul>	Level	PhD
	First Supervisor	Beatriz Sanchez-Cano
	Second Supervisor	Mark Lester
	Application Closing Date	19 January 2022
	PhD Start date:	26 September 2022

## Project Details:

Mars does not currently have a global dipole magnetic field, and as a consequence, the atmosphere of the red planet is in direct contact with the incoming solar wind (see Figure 1). However, a large part of the southern hemisphere and equatorial region is covered by remnant crustal magnetic fields, of variable strength and direction, which can interact with the solar wind in various complex ways as they rotate with the planet producing a “hybrid magnetosphere”. Consequently, the Martian plasma system has features of both induced and intrinsic magnetospheres, which in turn have strong effects on the dynamics of the ionospheric region [e.g. Sanchez-Cano et al., 2021].



Mars' plasma system



Ionosphere-Atmosphere couplings at Mars

The ionosphere of Mars is known to vary with the solar cycle, seasons, and even with atmospheric cycles produced near the surface, such as the CO<sub>2</sub> cycle (or sublimation of the polar caps) [e.g. Sanchez-Cano et al., 2016; 2018] (see Figure 2), and that the ionosphere over crustal field regions on the dayside is very different from that on the nightside, where these fields allow for solar wind particles to reach more easily the atmosphere resulting in additional ionisation [e.g. Andrews et al., 2015]. However, the dynamics of this region are not well understood because they are variable both in time and space, and we can only start now to draw the actual picture with multi-spacecraft observations.

The aim of this PhD project is to do the first comprehensive temporal and spatial analysis of the dynamics of Mars' ionosphere over crustal field regions. For that, three main aspects will be investigated:

1. The spatial and temporal evolution of the topside ionosphere and total electron content (TEC) during the solar cycle and seasons. The role of different magnetic fields will be examined through observations and models.
2. The short-term dynamics of this ionospheric region during solar wind quiet and active conditions, as well as how they compare to other regions far from crustal fields.
3. The role of particle precipitation in the ionosphere dynamics through crustal magnetic field lines connected to the solar wind.

This is a mainly data analysis project that will use data from the Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS) on board Mars Express, the well-suited plasma package from the Mars Atmosphere and Volatile Evolution mission (MAVEN) mission, and the Shallow Radar (SHARAD) on board the Mars Reconnaissance Orbiter (MRO). The full coverage of these missions expands near 16 years, from 2005 to the present allowing the first complete characterisation of this important region at Mars. Model-data comparisons of the ionosphere and magnetic fields are an additional value to this project.

The unique combination of multi-spacecraft datasets at Mars offers the potential for exciting new discoveries on the red planet. Successful PhD candidates would have some prior background in coding, as well as some prior knowledge of plasma physics and ionospheric science is desirable.

The supervisors of this project are Co-Investigators of the MARSIS instrument on Mars Express and coordinators of the Mars Upper Atmosphere Network (MUAN), which will provide unique opportunities to the PhD candidate to collaborate with colleagues from different international institutions. Moreover, Leicester's current involvement in Mars' exploration with Mars Express and ExoMars as well as on other planetary missions such as BepiColombo, SMILE, the Jupiter Icy Moons Explorer (JUICE), or the James Webb Space Telescope (JWST), offers a unique immersive experience on planetary research to the successful PhD candidate

## References:

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