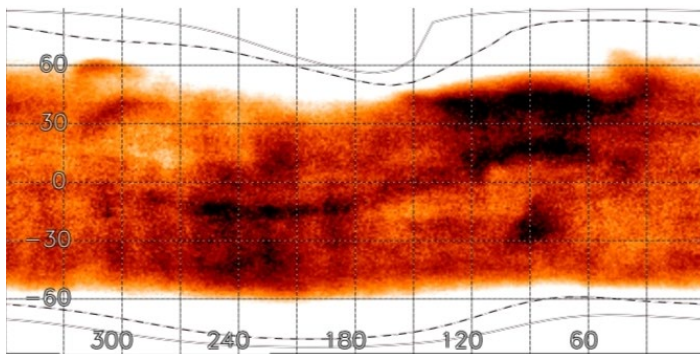


# Traces of Jupiter's magnetic field: the magnetic silhouette in Jupiter's ionosphere

- Ground-based infrared astronomy with the world's leading telescopes
- Revealing Jupiter's equatorial ionosphere in unprecedented details
- Directly comparing our measurements with Juno magnetic field models

Level	PhD
First Supervisor	Tom Stallard
Second Supervisor	Henrik Melin
Application Closing Date	19 January 2022
PhD Start date:	26 September 2022

## Project Details:



*A map of Jupiter's ionospheric brightness*

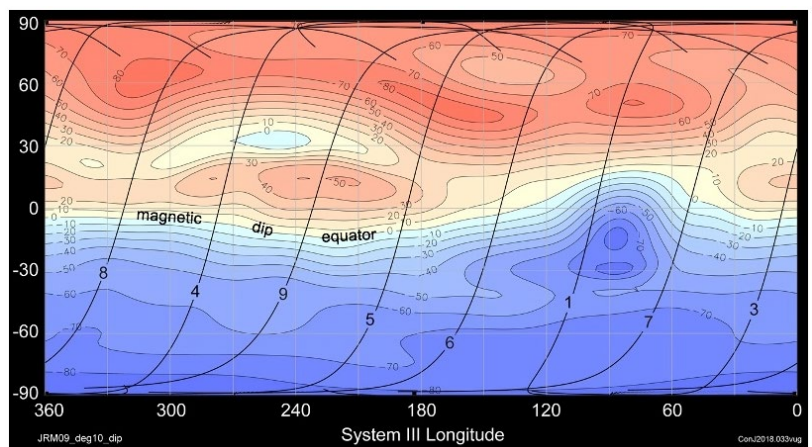
Until the past five years, the general understanding of Jupiter was that it had a dynamic and exciting aurora, but that its equatorial region was relatively dull and mundane. On reflection, that was a poor assumption on our part – Jupiter's magnetic field is far stronger than the Earth, and its lower atmosphere churns with far greater furiosity, yet Earth sees very complex equatorial ionospheric processes.

The reason we thought it so quiet was simply that we did not have detailed enough observations to see any variations. Our recent measurements,

over the past five years, have completely revolutionised our understanding of these regions – in a series of high impact papers we have shown the equatorial region to be far from simplistic. Instead, the energy from the auroral region washes down in great waves, sometimes driving what appear to be complex weather structures in regions close to the aurora. Down closer to the equator are vast regions of ionospheric brightening and darkening, perhaps analogous to the Southern Atlantic anomaly and the equatorial fountain seen at Earth.

At the same time, the Juno spacecraft has been measuring the magnetic fields in detail across this equatorial region. There, we have seen the detection of unexpected complexity in the magnetic field structures, with highly localised regions of strength and weakness that suggest a complex mix of magnetic sources within the planet.

It seems unlikely that the complexity we see in the ionosphere and that observed in the magnetosphere are unconnected, but we are yet to properly test that connection. If you compare the two maps, as shown in the images, you can immediately see that the ionospheric brightness seems to match with regions of



*Magnetic map from the Juno spacecraft*

magnetic strength changes, but we still don't have a good measure of why the brightness changes (it could be because these regions are hotter or colder, and glow more or less brightly, or it could be either enhanced ionisation, or higher destruction processes).

Fortunately, we have a wealth of data, taken with both the NASA Keck and IRTF telescopes, that we can use to test this. If you take on this project, you will be at the forefront of this test – taking our measurements of the ionosphere and analysing them to compare them with the quickly improving magnetic field measurements from Juno. You will be supported in this work both by our team at Leicester, and through an external supervisor Dr James O'Donoghue who works at the Japan Aerospace Exploration Agency. This represents the world's leading infrared upper atmospheres research team.

PhD candidates would benefit from some prior background in coding, as they will be using IDL and Python-based packages to analyse their data. Some prior knowledge of planetary atmospheric science, space plasma or infrared spectroscopy are also useful. However, while a more general background in physics is necessary, all these more specific skills will be encouraged during the PhD itself, providing a fantastic opportunity for specific research skills training.

Although we have a wealth of data already available, we would also strongly encourage your involvement in all aspects of future telescope observations. Past students have taken the lead in planning telescope campaigns, in leading the proposals through the telescope panels, and in observing Jupiter, Saturn and Uranus, both remotely from Leicester and in person at the telescopes in Hawaii. Although not an essential component of this research project, this represents an excellent opportunity to be directly involved in astronomy.

This research has huge potential for new, unique and ground-breaking science, and you will have the opportunity to share these results within the wider scientific community, through a combination of national and international meetings.

## References:

- 1 <https://www.nature.com/articles/s41586-021-03706-w>  
**Global upper-atmospheric heating on Jupiter by the polar aurorae**
- 2 <https://www.nature.com/articles/s41550-018-0523-z>  
**Identification of Jupiter's magnetic equator through H<sub>3</sub><sup>+</sup> ionospheric emission**
- 3 <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2016GL071956>  
**The Great Cold Spot in Jupiter's upper atmosphere**
- 4 <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2018GL077312>  
**A New Model of Jupiter's Magnetic Field From Juno's First Nine Orbits**