Solving Mysteries of the Ice Giant Planets

PhD project in the Space, Plasma and Climate Community, October 2026 start.
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In April 2022 the results of the Planetary Science & Astrobiology Decadal Survey were announced in the USA. **A mission to Uranus is NASA's highest priority planetary flagship over the next decade, with international plans to also go back to Neptune.** The reason for this focus on the "ice giants" is that they are a distinct class of planet in the Solar System, and they are barely explored. Their scientific potential is enormous, with numerous unsolved mysteries that have persisted since the brief flyby of each planet by the *Voyager 2* spacecraft in the 1980s.

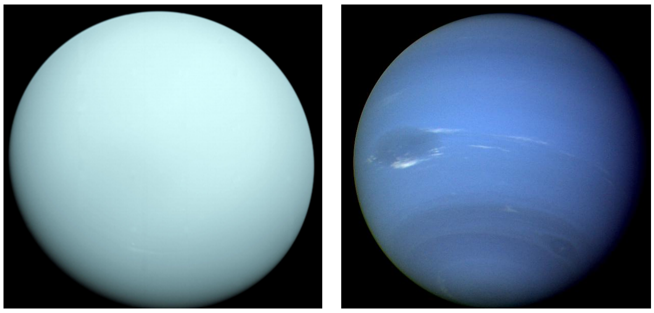

Figure 1. Uranus (left) and Neptune (right), as seen by Voyager 2*. Image credits: NASA.*

The aim of this PhD project is to learn new things about both Uranus and Neptune, creating the scientific foundation for future missions and potentially solving some of the persistent myseries. The project builds on our past and present leadership in these future mission projects, as well as our recent science results that have established us as one of the world-leading groups in this field.

During the first year the student will address the ice giant upper-atmosphere cooling problem, using data taken by spacecraft throughout the Solar System. The tenuous upper-atmopshere of a planet is known as the thermosphere. This region is heated by photons and charged particles precipitating from space, and it is where auroral emissions are generated. Limited remote monitoring by telescopes has shown that **the temperature of both Uranus' and Neptune's thermosphere has almost halved since ~1990, without explanation.** In December 2024 we put forward the first possible solution, suggesting it is due to long-term decline in the energy carried by the solar wind of charged particles away from the Sun, which is incident on the magnetic field of each planet [1]. A fraction of this energy heats each thermosphere.

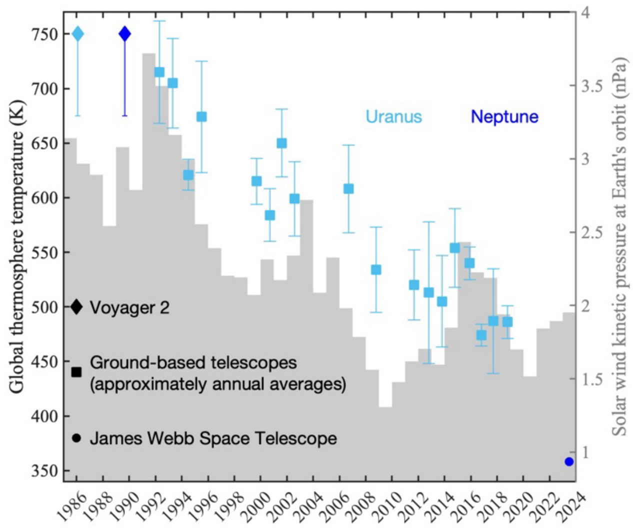

Figure 2. Long-term cooling of both Uranus' and Neptune's thermosphere (data points, left y-axis) compared to declining solar wind power (grey bar chart, right y-axis). Adapted from [1].

Using Python or similar software, the student will analyse solar wind measurements to test our solar-wind-driving hypothesis. They will examine long-term changes in solar wind properties, extrapolate conditions from Earth's orbit to these planets, and assess how the solar wind interaction with each planet's magnetosphere has been evolving over time. **Topics for later stages of the PhD will be decided with input from the student, with the ambitious possibility of moving towards closure of the cooling problem with high-performance computing.** This would involve collaboration with the team in the Community that uses the *Gorgon* code to model magnetised populations of charged particles in space as collisionless fluids. Other directions include likely seasonal "plasmaspheres" around Uranus and Neptune, explaining Uranus' intense electron radiation belt, and the unusual dynamics of these magnetospheres.

Within the group the student will join a team of researchers studying all the planets in the Solar System, More broadly, the student will also join the international ice giant science community that are actively planning future exploration. Prospective applicants are encouraged to contact the supervisor for further information.

[1] Masters, A., Szalay, J. R., Zomerdijk-Russell, S., & Kao, M. M. (2024). Solar wind power likely governs Uranus' thermosphere temperature. Geophysical Research Letters, 51, e2024GL111623. https://doi.org/10.1029/2024GL111623