I BET YOU DIDN'T KNOW...

Ice giants at the end of the Solar System

Prof. Dudley Shallcross, PSTT CEO, links **cutting-edge research** with the **principles of primary science**

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In the last decade, we have learned more about planets at the edge of our solar system, Uranus and Neptune (Figure 1). These so-called *ice giants* have been observed using telescopes on the surface of the Earth and more recently from the Hubble space telescope but there are limitations to what can be seen.

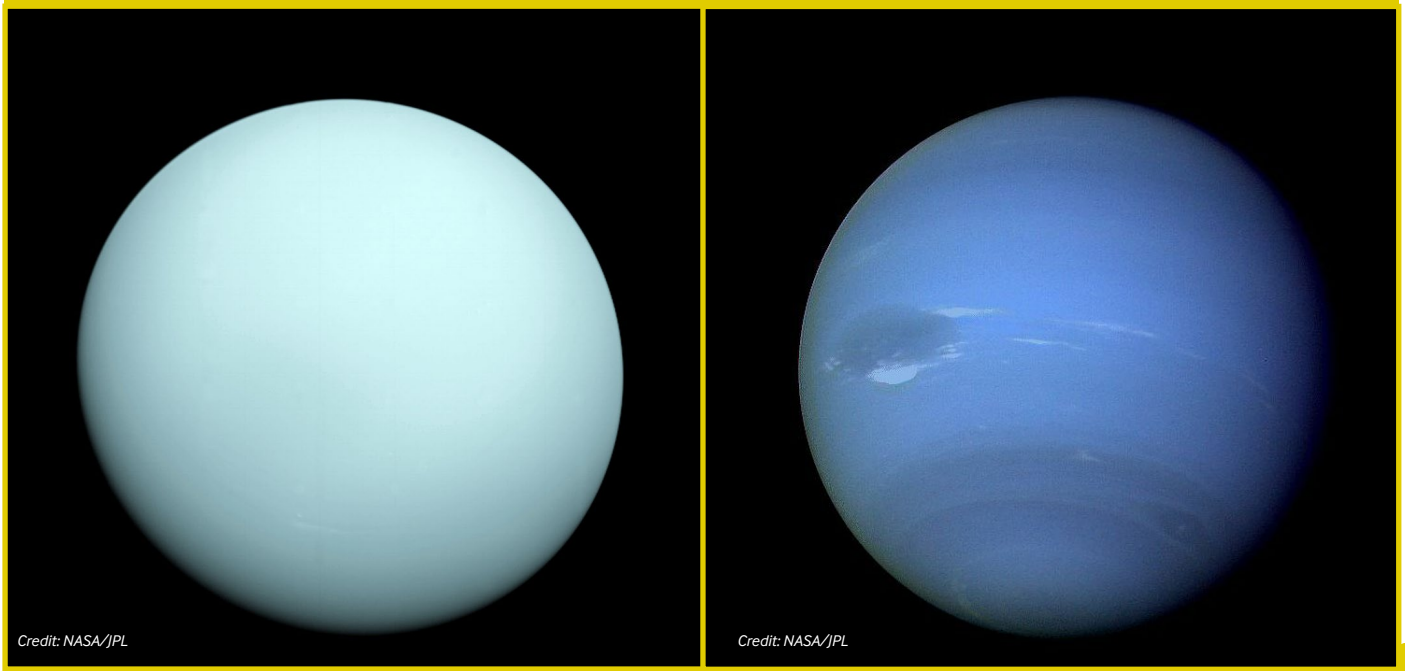
Discussion: What would you consider to be possible limitations in viewing planets from Earth or from the Hubble space telescope?

In this first of a series of papers, we look at some of the important facts that have been found about planets in our solar system in recent times. The Voyager 2 spacecraft (Figure 2) left Earth in 1977 and travelled to these worlds, reaching Uranus in 1986 and Neptune in 1989. In a recent paper, *Uranus and Neptune: Origin, Evolution and Internal structure*, scientists Ravit Helled, Nadine Nettelmann and Tristan Guillot collate all the information gathered about these planets.

Discussion: Why would a review like this be valuable to scientists?

Uranus and Neptune are the second and third *blue planets* in our solar system. The Earth is blue when viewed from space because of the water in the oceans. Is there liquid water on the surface of these ice giants? The clue is in the name *ice* giants; they are so far away from the Sun that they are much colder than the freezing point of water (0°C) and so any water would be in the solid form of ice. So why are they blue? The physical reason is the same as that found on Earth: white light from the Sun (which contains all the colours of the visible spectrum)

Figure 1. Methane in the atmosphere of the planets Uranus and Neptune absorbs red light and reflects blue. The planet Uranus (left) has more methane in its atmosphere than the planet Neptune (right), resulting in their different blues.



Credit: NASA/JPL

Credit: NASA/JPL

shines onto planet Earth and the water absorbs red light and so blue light is left and that is what we see. In the atmospheres of Uranus and Neptune, there is a lot of methane and this, similarly, absorbs red light and so the blue light is left. The difference in blueness between Uranus and Neptune is due to the different amounts of methane in their atmospheres (Figure 1).

In table 1, some basic facts about these worlds are summarised.

Figure 2. Voyager 1 and Voyager 2 were launched from NASA's Kennedy Space Center in 1977 and travelled to explore the outer planets – artist's impression.

Interesting facts

Earth: Life exists

Uranus: Spins on its side

Neptune: Fastest winds in the Solar System

Table 1. Data concerning Uranus and Neptune compared with the Earth.

	Earth	Uranus	Neptune
Mass relative to Earth	1	14.5	17
Radius of the planet in km	6,371	25,363	24,622
Distance from the Sun relative to Earth	1	20	30
Sunlight received relative to the Earth	1	1/400	1/900
Fraction of oxygen in atmosphere	21%	~0	~0
Time taken for light to travel from the Sun to the planet in minutes	8	165	249
Length of day in hours	24	17	16
Length of year in days	365	30,687	60,190
Average temperature in °C	16	~-214	~-200
Number of Moons	1	27	14
Life detected/possible	Yes	No	No

Given the facts in Table 1, what do you think it would be like to live on these planets?

Unlike on Earth, the Sun would be very faint in the sky on both planets; it would be about 400 times fainter on Uranus and 900 times fainter on Neptune. You might consider whether there are places on Earth where daylight is very faint and how this is different to these other planets.

A *day* is shorter on both planets compared with Earth: 17 hours for Uranus and 16 hours for Neptune. A *year* is much longer for both: 84 years for Uranus and 165 years for Neptune. Most Uranians and all Neptunians would be less than 1 year old (local time), so there would be little need for birthday cakes, candles and presents.

The weather on these planets is very different from Earth. Both are very cold, around 200°C below the freezing point for water and so it is assumed that there is no life as we know it on the planets. There is no discernible oxygen in their atmospheres and if you are on Neptune you would experience incredibly strong winds, the fastest winds in the Solar System, at 1,200 miles per hour - that is windy.

It took the Voyager 2 spacecraft around 9 years to reach Uranus and 12 years to reach Neptune so if you were to forget something or if you needed something, it would take a long time for a spacecraft to get to you with it. If you could see through the planets' atmospheres, or you were orbiting either in a spaceship, you would have a number of moons to look at each night and see some faint rings of space rock as well. The sizes of the planets are very different to that of Earth: the radius of both Uranus and Neptune are about 4 times larger and so travelling around the planet would take many days; the masses are 14.5 and 17 times larger.

Neptune, named after the Roman God of the Sea, was first observed in 1846 by Johann Galle and Uranus, named after the Greek God of the sky, was first observed by William Herschel in 1781. The last known fact is that Uranus rotates on its side (its axis is at 90°C to that of the other planets) and is known as a *sideways planet*.

Discussion: What impact would this have on life on Uranus?

However, there are still many mysteries about these two planets and the review highlights these. Here are some that children may like to think about:

Where and how are the magnetic fields generated?

On Earth, there is a magnetic field created by its iron core. We can use it for navigation (compasses contain magnets) and this also protects us from dangerous cosmic storms from the Sun. On the ice giant planets, magnetic fields have been detected. Perhaps, like scientists, children can speculate about why this occurs on these planets too.

Do the planets have water oceans?

It is too cold for liquid water to exist on the planets' surfaces but perhaps it is warmer lower down in the planets, where water could exist in liquid form? How might we detect it if it did exist? Can we imagine what an ocean deep in the core of the planet would look like?

What are the causes of the observed differences between the two planets?

Perhaps children could suggest ideas, e.g. one formed before the other. What impact might this have had and what differences might have occurred if they were formed at the same time? What if they were constructed from very different materials? It is thought that Neptune has a lot of radioactive material in its core that provides a lot of heat and that Uranus has very little of this material and is much more inactive as a result.

Did the planets suffer from giant impacts?

How could we work this out? Look at craters on the surface? Count how many? Measure their size? Could a giant impact explain why Uranus spins on its side? Are there other suggestions?

How do we know everything we know about these planets?

It takes a very powerful telescope to observe these planets because they are so far away. However, light from the planets can be analysed and this tells us about the chemicals present in the atmosphere. Each chemical has its own 'fingerprint' in different parts of the light spectrum. The Voyager 2 spacecraft provided a lot of measurements close up to the two planets and had detectors that could observe particles, ultraviolet light, visible light, infrared light, cosmic rays, and sensors to detect magnetism as well as cameras to take images.

What additional information would children like to know about these planets and how might they obtain this information?

Voyager 2 and Voyager 1 are still travelling in space and you can follow their voyage at the dedicated NASA websites:

Voyager 1 https://solarsystem.nasa.gov/missions/voyager-1/in-depth/

Voyager 2 https://solarsystem.nasa.gov/missions/voyager-2/in-depth/

A big question is **why do we want to study the solar system?**

NASA is planning to send a new spacecraft to study these planets again. You may also want to look at exoplanet research, an exciting new area of astronomy.

The Teacher Guide that accompanies this series of *I bet you didn't know...* articles on planets includes activities that enable children to learn more about the Earth and space, the processes of science research and to develop their own enquiry skills.

Activities that are relevant to this article include:

- Exploring mixing colours of light
- Splitting white light to observe a spectrum of colours
- Modelling planetary motion around the Sun

GLOSSARY

blue planets
planets that appear to be blue in space. In our solar system the blue planets are Earth, Uranus and Neptune

day
the time taken for the planet to rotate on its axis

ice giants
this term is used to describe two planets in our solar system (Uranus and Neptune) though relatively little solid ice is thought to be in them today. It is believed there is a massive liquid ocean beneath their clouds, which accounts for about two-thirds of their total mass

year
the time taken for a planet to travel all the way round the Sun once

The paper that inspired this work was:

Uranus and Neptune: Origin, Evolution and Internal structure.

By Ravit Helled[1], Nadine Nettelmann[2] and Tristan Guillot[3] .

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One of the authors, Prof. Ravit Helled, has been recognised as being a 'highly influential woman'.

Why do you think this is?

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