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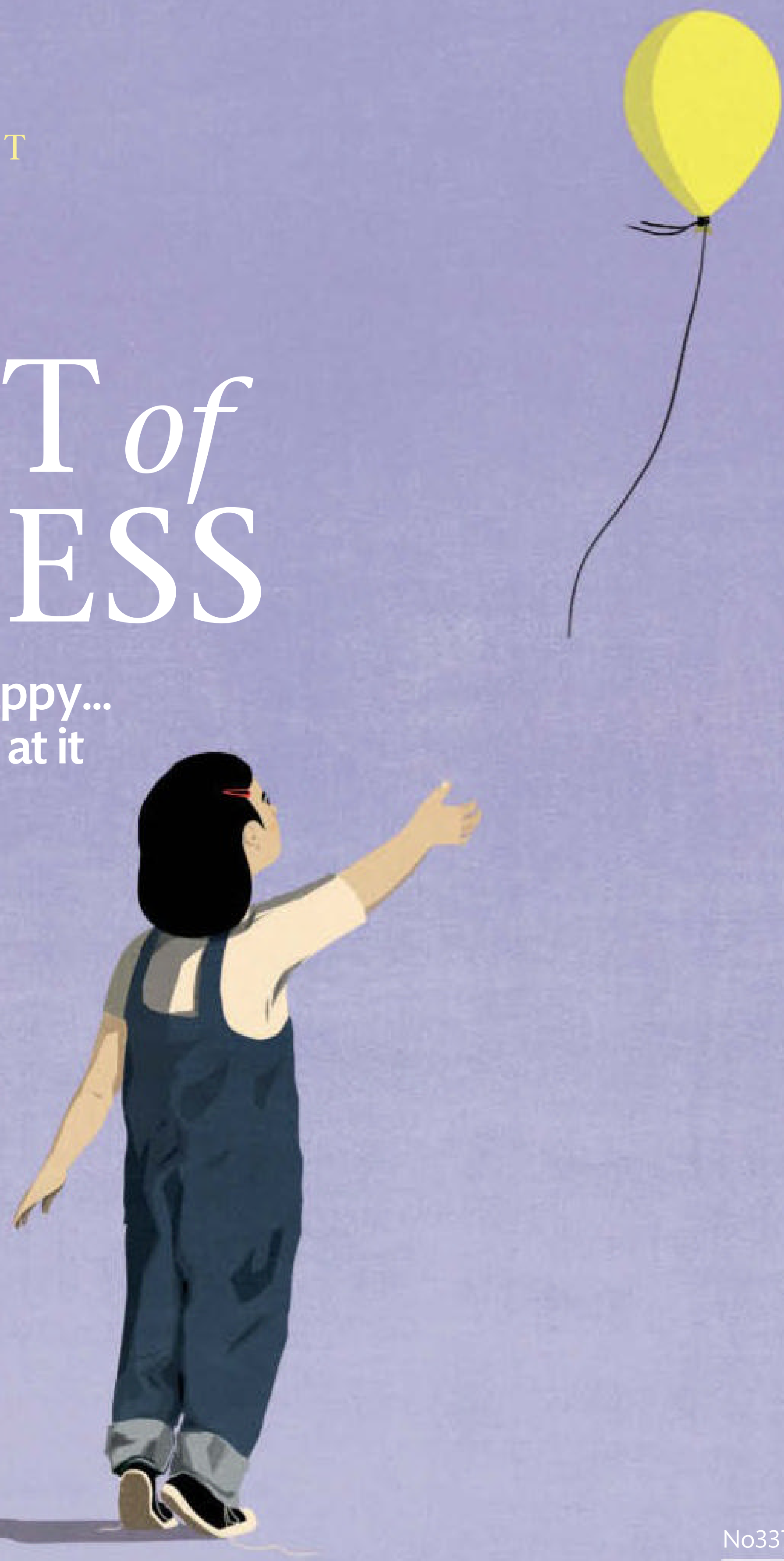

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Ice dreams

A dedicated mission to Neptune or Uranus is the next step in exploring our solar system and fathoming worlds elsewhere in the galaxy. But we must act fast, planetary scientist **Leigh Fletcher** tells Becca Caddy

BEFORE heading into the depths of interstellar space, the Voyager 2 probe flew by the giant icy worlds on the edge of our solar system, giving us our first ever close-up of Uranus in 1986 and Neptune in 1989. These passes were fleeting, but the data the spacecraft collected about the two planets showed us previously unknown icy moons and dusty rings, unusual magnetic fields and dramatic plumes of nitrogen on the surface of Neptune's moon Triton.

Voyager 2 now flies through the empty space between the stars, more than 19 billion kilometres away from Earth. The glimpse it gave us of Uranus and Neptune is still the closest we have ever got to these ice giants. But Leigh Fletcher, professor in planetary sciences at the University of Leicester, UK, thinks now is the time to go back.

Fletcher studies the atmospheres, weather systems and climates of planets. He has explored Saturn's seasonal atmosphere and peeked beneath Jupiter's clouds. He told *New Scientist* how a voyage to the ice giants would unlock secrets about our solar system's past and teach us about planets scattered across the galaxy.

Becca Caddy: What is the most exciting part of your job?

Leigh Fletcher: I can close my eyes and imagine what it would be like to fly through the skies of Jupiter, or walk on the surface of Mars and gaze up at the carbon dioxide clouds, dust storms and pinkish hues of the sky.

Planetary exploration is something I can see humans doing in the future. Today, we are taking the first steps to characterising these environments. But someday, somebody might experience what I am seeing in my data sets and observations. Our children's children's children's children might see these worlds with their own eyes. That is what gets me excited about what I do.

Before we discuss the ice giants, how does it feel to be part of the Jupiter Icy moons Explorer project, an orbiter that will visit Jupiter and three of its moons – Ganymede, Callisto and Europa?

It has been fabulous to see a mission go from a concept on paper – literally, we call them paper missions – to seeing the spacecraft knowing it will be heading to Jupiter in 2023.

I like to think of all four giant planets – Jupiter, Saturn, Uranus and Neptune – as time capsules for the composition of the solar system. As these planets formed, they were so enormous that anything sucked in while they were growing hasn't been able to escape. Within them are the chemical fingerprints of the protoplanetary disc: the cloud of gas, ice, dust and rocks that formed around our young sun and clumped together to form the planets. Understanding the formation of our giant planets gives us a window on the formation of giant worlds in solar systems beyond our own.

What more can we learn from visiting planets compared with observing them from Earth?

Earth's atmosphere is only transparent at certain wavelengths and completely opaque at others. We're also limited by the size of [telescope] mirrors we can build.

We need a spacecraft in a planet's orbit to observe for an extended period. That is remote sensing and what my research is based on. We also need to be there doing active sensing and direct measurements, and even descending into atmospheres and sampling the gases, the aerosols, measuring the temperature, listening for crackling lightning and being blown around by the winds – things you can only do when you're there.

We have flown by Neptune and Uranus in the past. Why do we need to go back there?

The ice giants are a class of planets all by themselves. They are substantially smaller than the gas giants and substantially larger than the terrestrial planets we have in the solar system. So they could be the closest representatives in our solar system of mini-Neptune worlds – slightly smaller in size than Neptune – which appear to be among the most common types of planet in the universe. They may not have exactly the same conditions. But

Journey to the ice giants
Catch Leigh Fletcher at our live show on 12 March
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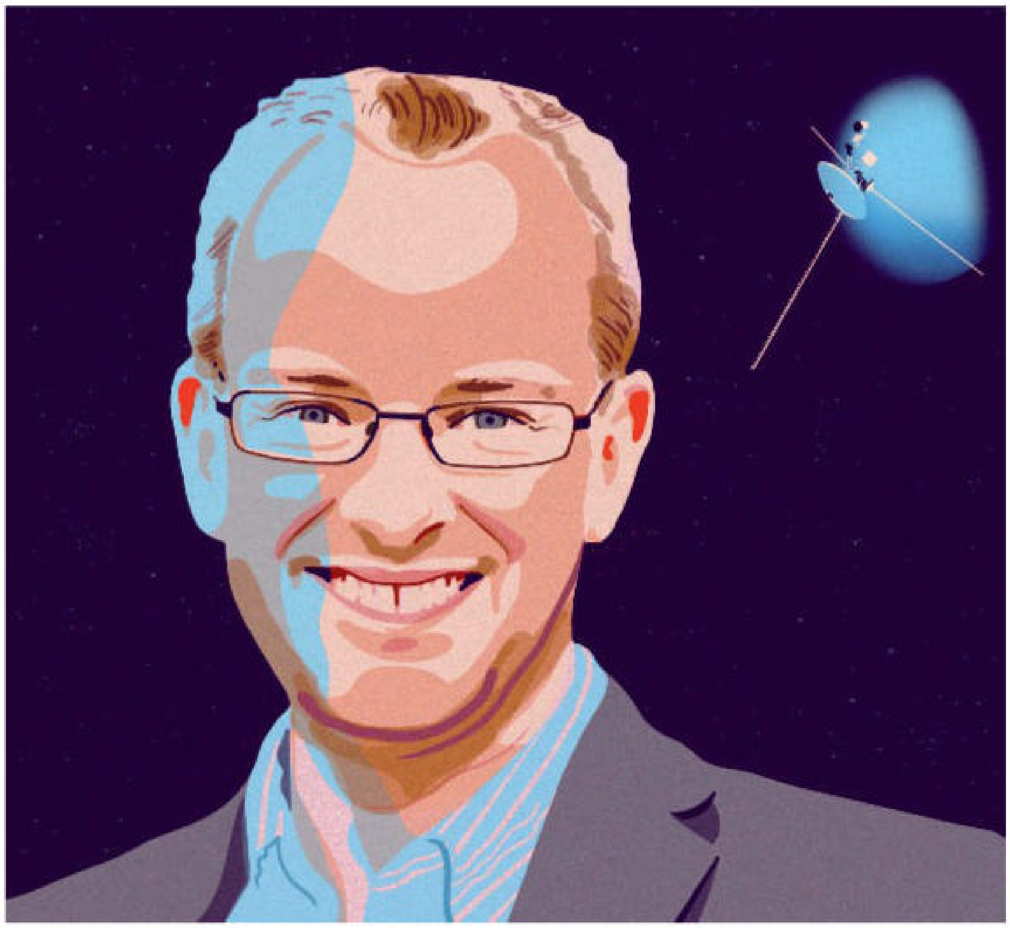
JENNIE EDWARDS

we need to understand our giant ice worlds before we can understand the vast population of similar planets in the galaxy.

We've only visited once. Now is the time for a mission to Uranus or Neptune to explore one of the planets, its extended magnetic field, atmosphere, satellites and ring systems.

What are the big mysteries about these worlds?
Neptune is giving off two and a half times more energy than it is receiving from the sun. No other planet has such a powerful internal energy source. This makes Neptune's weather powerful, with storm systems and clouds evolving on hourly timescales. But Uranus has no internal energy source we can detect. An orbiter would measure the distribution of materials within the planets to determine why they're different.

Both planets have complicated magnetic field environments, unlike anywhere in the solar system. There is a complex, twisted, evolving system and we've only had one data set from Voyager 2 to understand it. We need to be in orbit, sampling how it changes over several years.

A mission could also sample the various gases, ices and rocks, allowing us to find out why the ice giants formed and why they are different to the gas giants. This could be unique to our solar system. But it could also be the most common outcome of planet formation; Jupiter and Saturn-style planets could be rare. The formation of the icy giants is the missing piece in the puzzle of planetary evolution.

What about the icy moons around the ice giants?
The classical satellites of Uranus, like Titania, Oberon and Ariel, could be ocean worlds. We expect to find a crust of ice above a deep, dark, hidden liquid ocean if they are. If there is liquid water, that is an excellent solvent for chemistry. You only have to add in the right balance of nutrients or chemicals to have a habitable environment.

We need to identify the properties of these oceans to assess if they are potentially habitable. Triton could be an ocean world and is a fascinating, unique environment. For example, Voyager 2 showed us it has plumes of gas and dust that rise 8 kilometres above its surface.

> "Now is the time for a mission to explore Uranus or Neptune"

How hard would it be to get to Neptune?
You could go [direct] with a conventional rocket, but it would take 15 to 20 years. The sensible way is to use Jupiter for a gravitational slingshot. Cassini did this when it went to Saturn. But Jupiter has to be in the right place in the solar system, which only happens every 12 to 13 years. We missed the last opportunity to do this, but the next is in the early 2030s. At the moment, NASA is planning its strategy for the next 10 years. We'll find out [what it is] in March. If decisions happen quickly, we have the chance to make the most of Jupiter's position and get to the icy giants by the 2040s.

What about worlds beyond our solar system?
The timescales involved are so immense that no technology we have today can travel [that far] within our lifetimes. However, I like to keep an open mind. There might be a technology around the corner that could shorten those durations. More feasible are enormous telescopes in space that could look at the atmospheres, even the distribution of clouds or continents, on a distant world. I can imagine that in my lifetime. ∎


Becca Caddy is a freelance writer based in London