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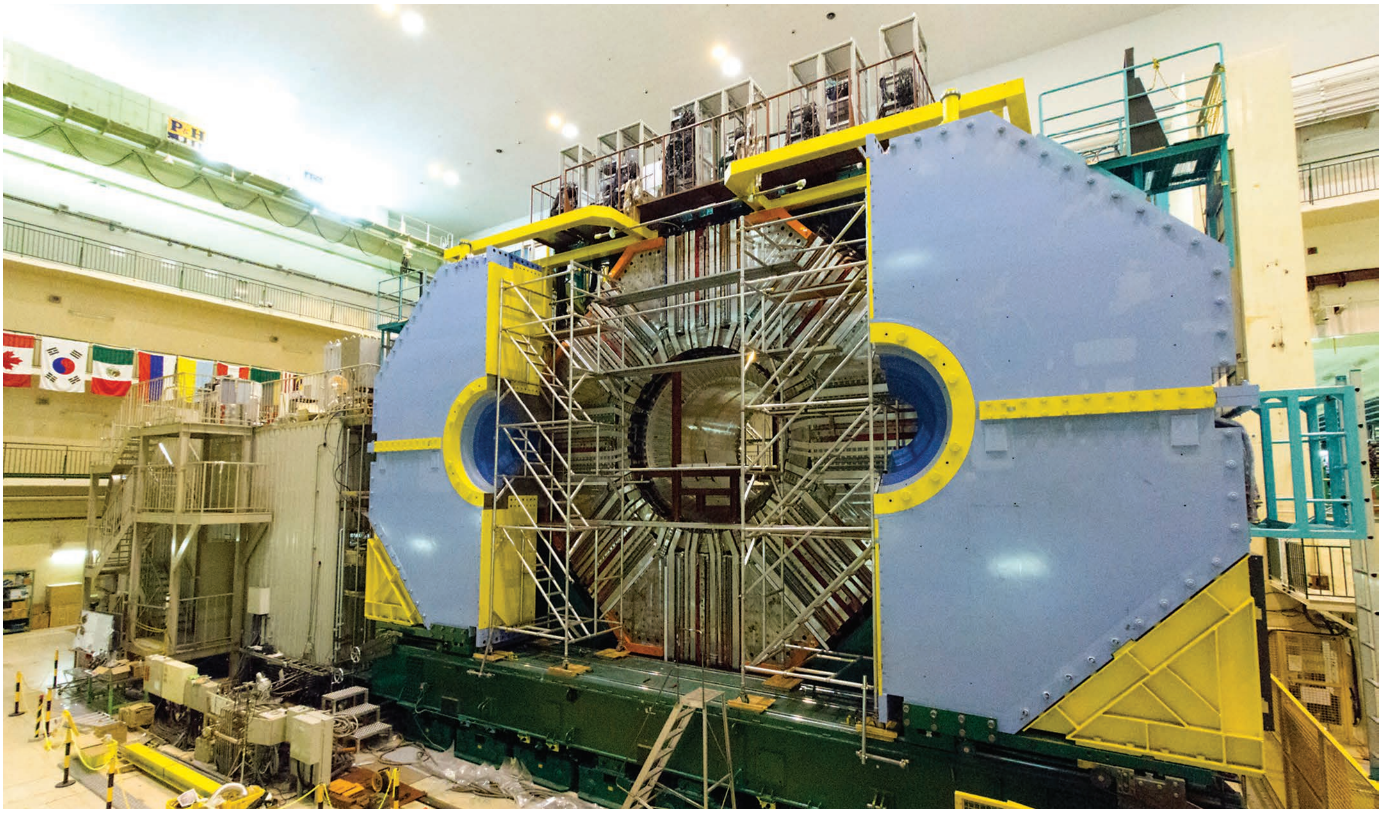


KEK/BELLE II

The Belle II experiment at the High Energy Accelerator Research Organization (KEK) in Tsukuba, Japan.

PARTICLE PHYSICS

Collider seeks cracks in physics framework

The Belle II experiment in Japan will search for missing pieces in the standard model.

BY ELIZABETH GIBNEY

The quest to explore the frontiers of physics will heat up in Japan next month, when beams of high-energy electrons are set to start smashing into their antimatter counterparts at one of the world's premier accelerator laboratories. The experiment, called Belle II, aims to chase down rare, promising hints of new phenomena that would extend the standard model — a remarkably successful, but incomplete, physics theory that describes matter and forces.

In February, an accelerator at Japan's High Energy Accelerator Research Organization (KEK) in Tsukuba will begin an initial six-month run of collisions. The eventual goal is to chart in high precision the decays of B-mesons, which contain a fundamental building block of nature known as a the b quark ('b' stands for 'beauty' or 'bottom').

The work builds on B-meson observations made by experiments including those at the Large Hadron Collider (LHC) at CERN, Europe's particle-physics laboratory near Geneva, Switzerland. Both efforts are looking for the subtle influence of any new particles or processes on the ways in which known particles decay into others.

Physicists at the LHC have seen some intriguing signs of potential departures from the standard model, most recently in 2017 (The LHCb collaboration *et al. J. High Energ. Phys.* **2017**, ▶

► 55; 2017). Buzz around these results has piqued theorists' interest in Belle II, and has prompted new groups to join the international collaboration, says Tom Browder, a physicist at the University of Hawaii at Manoa and spokesperson for the Japan-based experiment.

CLEANER PHYSICS

The collisions at the Belle II experiment will be cleaner and more precise than those at the LHC experiment, called LHCb. That is because the LHCb experiment smashes together protons, which are each composed of three quarks and so make for messy collisions. But Belle II will crash electrons and positrons into each other, both of which are fundamental and so cannot break down any further.

Belle II will be able to study decays involving elusive neutrinos and photons that are harder to investigate with LHCb. This could help it to spot evidence for hypothetical particles, such as charged versions of the Higgs boson — a particle discovered at the LHC in 2012 — and particles such as the axion, a form of dark matter thought to interact with matter only very weakly, says Browder. "There's definitely competition between the two, but also complementarity."

The collider feeding the Belle II experiment will squeeze particles into a tight beam just 50 nanometres across, an advance that will lead to a collision rate 40 times that achieved by its KEK predecessor. This will help it to explore reams of recently discovered exotic particles made up of four or five quarks — tetraquarks and pentaquarks, respectively — and allow it to scour rare b-quark decays for any as-yet unknown preference towards the production of matter over antimatter. It will enable physicists to explore intriguing signs of physics beyond the standard model, a theory that has been verified repeatedly by experiments since the 1970s, but which fails to account for gravity or a host of other mysteries.

Collider experiments produce sprays of many particles that can live for tiny fractions of a second before decaying into other particles. In a handful of decays — involving the transformation of certain B-mesons into electrons and their heavier cousins, called muons and taus — LHCb has seen particles produced at unexpected rates.

It will enable physicists to explore intriguing signs of physics beyond the standard model.

Although each individual finding could easily be a statistical fluctuation, together they have gained attention, says Giovanni Passaleva, a physicist at the National Institute for Nuclear Physics in Florence, Italy, and spokesperson for the LHCb experiment. They broadly point in the same direction and build on similar findings from two previous experiments: the BaBar Collaboration at the SLAC National Accelerator Laboratory in Menlo Park, California; and Belle II's predecessor at KEK, he says. "So it looks like there is some correlation in these deviations, which make them more interesting than others."

SCHEDULED CATCH-UP

However, Belle II will need to catch up with LHCb, whose accelerator produces more B-mesons and has been running since 2009. Once the full physics programme gets under way at the start of 2019, Belle II will take around a year to gather enough data to compete with LHCb. Meanwhile, LHCb will collect data from May until it shuts down for upgrades in November. By then, it should have seen enough decays to either dispel the potential signal or push it into discovery territory. "Our hope is that we get the machine and the detector working fast enough so we can start to catch up with them," says Browder.

The race to claim discovery will come down to which decays prove the most revealing, says Browder. But even if LHCb gets there first, confirmation of new physics from Belle II will be "absolutely essential", says Passaleva. Differences between the two experiments mean that Belle II could help physicists to work out what is behind any new interaction, and definitively rule out experimental error. "Then we'd be sure it's really new physics," he says, "because it will be seen by a completely different experiment in a completely different environment." ■

IMMIGRATION

Uncertainty grows for US 'Dreamer' scientists

Court temporarily revives protections against deportation as Congress mulls policy reform.

BY CHRIS WOOLSTON

Like other young researchers in graduate school, Evelyn Valdez-Ward has a lot on her plate. An ecology student at the University of California, Irvine, she has been running field experiments and scrounging for research funding. But, above all, she is worried about whether she can stay in the United States. "My first year has been a real whirlwind," she says. "On top of how difficult grad school is, Trump got elected."

Her future depends on a US government programme that the president, Donald Trump, has attempted to shut down. Known as Deferred Action for Childhood Arrivals (DACA), it shields nearly 800,000 people from deportation, all of whom were brought to the United States illegally as children. Last September, Trump moved to end the programme, prompting a flurry of lawsuits. On 9 January, a federal judge in San Francisco, California, ordered the government to continue DACA while one of the court cases proceeds.

That is little comfort to Valdez-Ward. "If DACA expires, there's no way I can finish my PhD. I would lose everything."

Former president Barack Obama established the DACA programme in 2012 to give young, undocumented immigrants access to legal employment and more forms of financial aid for university studies. To enrol, immigrants must prove that they came to the United States before their sixteenth birthday and have a high-school diploma or are studying for one, among other requirements. Those who are granted DACA status — known as Dreamers —must apply to renew it every two years. Without such protections, they risk being sent back to countries they might not remember, and whose language they might not speak.

Trump's move last year to end DACA prompted lawsuits from 19 states and Washington DC, among other challengers. The case that ultimately led federal judge William Alsup to order DACA's reinstatement was filed by the University of California system — which estimates that some 4,000 of its students are in the country illegally, and that many are probably eligible for DACA status.

"DACA empowered people to start making

DREW ANGERER/GETTY

Many people are pushing for legislation that would give US 'Dreamers' a path to citizenship.

investments in their future, to go to college and medical school," says Roberto Gonzales at Harvard University in Cambridge, Massachusetts, who studies how immigration policies affect the lives of undocumented US immigrants. "Now, that's been thrown into peril."

DACA helped engineering student Josue De Luna Navarro to attend the University of New Mexico in Albuquerque. But he fears that the programme could end. "I remember sitting in a chemical-engineering class trying to calculate a molecule moving through a membrane," he says. "How can I focus on something like that when there's a huge terror in my family and my community about deportation?"

Trump and the US Congress are attempting to negotiate legislation to overhaul US immigration policies — which could end DACA, or shore up the programme. On 11 January, a group of six Democratic and Republican senators announced a compromise that would give DACA recipients a path to citizenship while bolstering border security, but Trump rejected the plan. He has argued that Obama lacked the authority to establish the DACA programme.

Ongoing court cases might determine DACA's short-term future, but its ultimate fate lies with Congress, says Michael Olivas, director of the Institute for Higher Education Law and Governance at the University of Houston in Texas. "This is not a legal issue," he says. "Comprehensive immigration reform, or at least a DACA bill without a bunch of other things attached to it, is the answer." ■

GENETICS

Synthetic species can elude gene mixing

Engineered organisms cannot breed with wild cousins.

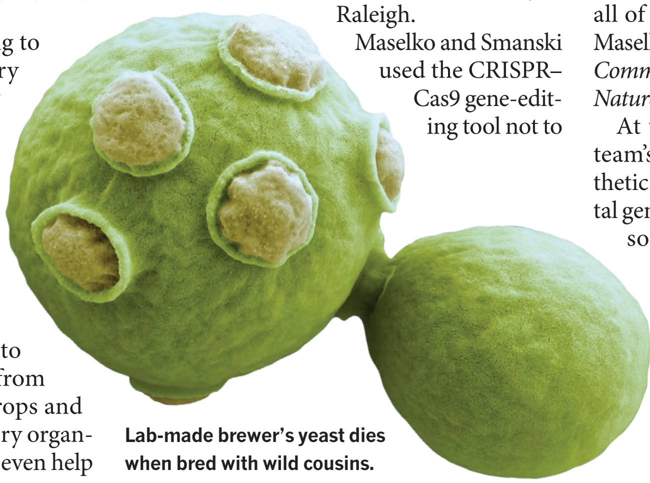
BY EWEN CALLAWAY

Maciej Maselko has made wild sex deadly — for genetically modified organisms. The synthetic biologist at the University of Minnesota, Twin Cities, in St Paul and his colleagues have used gene-editing tools to create genetically modified yeasts that cannot breed successfully with their wild counterparts. In so doing, they say they have engineered synthetic species.

"We want something that's going to be identical to the original in every way, except it's just genetically incompatible," says Maselko, who presented his work on 16 January at the annual Plant and Animal Genome Conference in San Diego, California. The research was co-led by Michael Smanski, a biochemist at the University of Minnesota.

The technology could be used to keep genetically modified plants from spreading genes to unmodified crops and weeds, thereby containing laboratory organisms, the researchers hope. It might even help combat pests and invasive species, by replacing wild organisms with modified counterparts. Other scientists say that the approach is promising, but warn that it could be stymied by technical hurdles, such as the ability of modified organisms to survive and compete in the wild. "This is an ingenious system and, if successful, could have many applications," says evolutionary biologist Fred Gould of the North Carolina State University in Raleigh.

Maselko and Smanski used the CRISPR–Cas9 gene-editing tool not to edit target genes, but to alter their expression. The team guided the Cas9 enzyme to over-activate genes so that their protein products accrued to toxic levels. When they first tested the approach in brewer's yeast (*Saccharomyces cerevisiae*), they raised the levels of a protein called actin to the extent that the cells containing it exploded.



EYE OF SCIENCE/SPL

Lab-made brewer's yeast dies when bred with wild cousins.

To prevent genetically modified yeast cells from mating successfully with other strains, the team engineered two modifications to the yeast cells. One change was analogous to a 'poison': it produced a version of Cas9 that worked with other factors to recognize and over-activate the actin gene. The second modification, the 'antidote', was a mutation that stopped Cas9 from overexpressing actin.

A yeast strain that contained both poison and antidote produced healthy offspring when mated with a strain carrying the antidote. But when the modified strain was crossed with a different lab strain lacking the antidote, almost all of their offspring popped like balloons, Maselko and Smanski's team reported in *Nature Communications* in October (M. Maselko *et al. Nature Commun.* **8,** 883; 2017).

At the meeting, Maselko discussed the team's progress towards engineering a synthetic species of fruit fly, using a developmental gene called wingless as a poison. Work will soon commence in plants, mosquitoes, nematodes and zebrafish, says Maselko, who, with Smanski, has applied to patent the approach.

A COUNTER TO INVASION

A synthetic species could also be used to outcompete and control undesirable species that spread ▶

disease or harm ecosystems. In another contribution to the conference, Maselko's colleague Siba Das, also at the University of Minnesota, presented a mathematical model showing how synthetic speciation could combat invasive carp, which have ravaged rivers and lakes in Minnesota and other central US states.

However, the genetic modifications that stop interbreeding — the poison and antidote — could carry a steep evolutionary fitness cost, says Omar Akbari, a molecular biologist at the University of California, San Diego. The Cas9 enzyme doesn't always recognize its intended gene and could crank up the activity of other genes. Such 'off-target effects' could sap the health of modified organisms. "I'm not sure if this is going to generate a fit-enough strain to compete in the wild," Akbari says.

Gould agrees that it will be difficult to engineer reproductive barriers without incurring evolutionary costs. Scientists could potentially overcome this obstacle by releasing large numbers of modified organisms to increase the odds that a synthetic species will overtake wild organisms. Still, Gould — who is working on other genetic approaches to combating pests — is enthusiastic to see another technology. "I would never want to put all my eggs in one basket," he says. ■

MACHINE LEARNING

Chinese firms enter the battle for AI talent

Country's ambition to become global leader in artificial intelligence needs large workforce.

BY DAVID CYRANOSKI

A mountainous district in western Beijing known for its temples and mushroom production is tipped to become China's hub for industries based on artificial intelligence (AI). Earlier this month, the Chinese government announced that it will spend 13.8 billion yuan (US$2.1 billion) on an AI industrial park — the first major investment in its plan to become a world leader in the field by 2030.

But scientists there wonder whether the proposed 55-hectare AI park, in the Mentougou district 30 kilometres away from the city centre, will be able to attract enough researchers. The government wants it to house 400 companies that will make an estimated 50 billion yuan per year developing products and services in cloud computing, big data, biorecognition and deep learning. "I don't see any top talent willing to go to work and live there," says a scientist working at an AI start-up in Beijing, who asked to remain anonymous because the government is sensitive to criticism.

Sourcing accomplished AI researchers is a problem that's confronting AI-related companies and research centres around the world. "The future [of AI] is going to be a battle for data and for talent," says David Wipf, lead researcher at Microsoft Research in Beijing.

TALENT GRAB

Chinese AI companies are progressing at a dizzying pace. At least five companies developing facial recognition technologies — including SenseTime and Face++, both based in Beijing — pulled in more than $1 billion from investors in 2017. But many AI companies there are struggling to hire researchers. In 2016, the information-technology ministry estimated the country needed an additional 5 million AI workers to meet the industry's needs.

The global pool of experienced AI talent is small. Chinese businesses also have to compete with the aggressive hiring techniques of multinational players such as Google, which some fear are draining universities of researchers by tempting them with high salaries. "It's a talent war — whoever makes the best offer wins," says Nick Zhang, president of the Wuzhen Institute, an AI think tank. He knows of experienced people getting salary offers of $1 million or more to work at the AI research centres of Chinese social-media giant Tencent or the web-services firm Baidu. "This was unimaginable five years ago," he says.

LI XIN/XINHUA VIA ZUMA

Zhang Yong, head of Chinese tech giant Alibaba, introduces the company's AI, called ET Brain, in 2017.

Accomplished industry veterans might be scarce in China, but the country is rich in bright, hard-working computer-science graduates who have expertise in machine learning and other AI-related fields. Peking University in Beijing established the country's first undergraduate course in AI in 2004, and since then 30 universities have introduced similar courses.

But universities are struggling to meet industry's demands, especially because many of the best graduates leave the country. Young Chinese researchers populate AI laboratories from the United States to Israel. At a December 2017 workshop held at New York University (NYU) Shanghai, called Future Leaders of AI Retreat, almost all of the attendees were Chinese researchers working at US universities or industrial laboratories. Zhang Zheng, an AI researcher at NYU Shanghai who organized the retreat, says that he often writes letters of recommendation for Chinese students to study in the United States. "The hope is for them to return later on in their career trajectories," he says.

There's also stiff competition for AI researchers within China. Most of the country's leading AI scientists go to work in industry rather than in academia, says Zhang Zheng. Wipf says that Microsoft set up in Beijing partly to hire the best graduates coming out of nearby Peking and Tsinghua universities, the nation's premier higher-education institutions.

Last month, Google also established its own AI research centre in Beijing to attract these prodigies. Zhang Zheng says it's good for the Chinese AI community that international companies are setting up there, because US companies such as Google and Facebook do more fundamental research than local tech giants, he says. "China is lacking top talent, and [working at China-based foreign research hubs] is a way to train them."

AI TRAINING

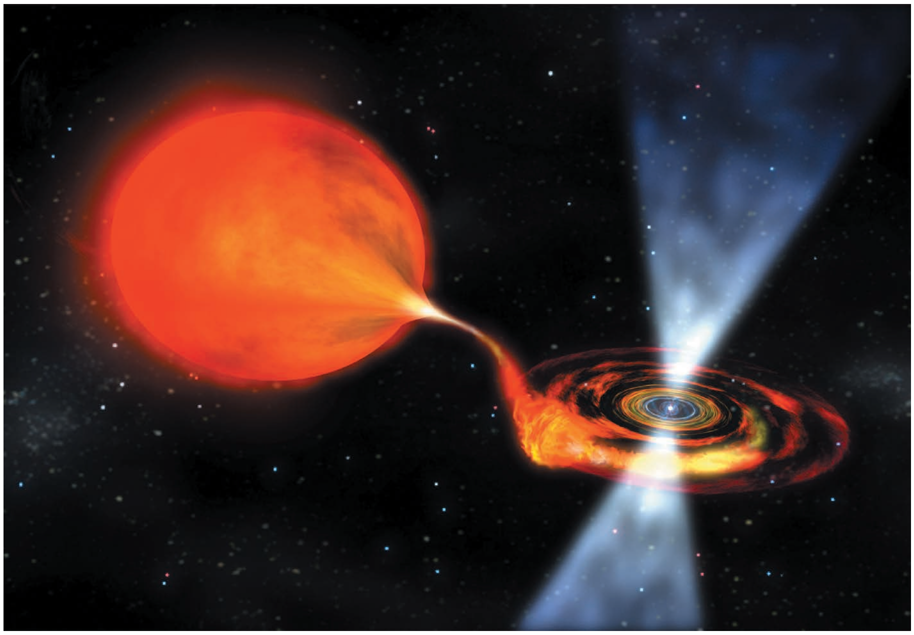
The Chinese government realizes that it needs to train and retain more AI graduates if it is to become the world leader in the field by 2030. Its AI road map, released by the Communist Party's powerful State Council last July, calls for increased education in AI at primary and middle schools.

Online AI training courses are also becoming popular. "The enthusiasm for learning AI is very high," says Zhang Jiang, who teaches AI at Beijing Normal University's School of Systems Science.

The country still trails behind the United States in most AI indicators, such as private investment and number of patents, according to figures from the Wuzhen Institute. Nick Zhang says that gap is closing fast, especially in applications such as computer vision.

There's greater uncertainty about whether China will be able to achieve pioneering breakthroughs in the next decade. "There is still a very big gap before China can lead the competition, because it lacks fundamental innovations," says Zhang Jiang. "China is still a good learner, but not a good innovator." ■ SEE EDITORIAL P.249

DANA BERRY/NASA



A pulsar (artist's impression) gives off beams of radiation as it sucks matter from a companion star.

SPACE SCIENCE

Pulsars can function as a celestial GPS

Experiment shows how spacecraft could use stellar signals to navigate in deep space without human instruction.

BY ALEXANDRA WITZE

From its perch aboard the International Space Station, a NASA experiment has shown how future missions might navigate their way through deep space. Spacecraft could triangulate their location, in a sort of celestial Global Positioning System (GPS), using the regular, rhythmic signals from distant dead stars.

Last November, the Neutron Star Interior Composition Explorer (NICER) spent a day and a half looking at a handful of pulsars — rapidly spinning stellar remnants that give off beams of powerful radiation as they rotate. By measuring tiny changes in the arrival times of the pulses, NICER could pinpoint its location to within 5 kilometres.

It is the first demonstration in space of the long-sought technology known as pulsar navigation. One day, the method could help spacecraft steer themselves without regular instructions from Earth.

"We think it's a big deal," said Keith Gendreau, an astrophysicist at NASA's Goddard Space Flight Center in Greenbelt, Maryland, and the mission's principal investigator. "It's a great way to apply some of our astrophysics to exploration goals that include going into the outer Solar System and beyond." ▶

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Gendreau reported the findings on 11 January at a meeting of the American Astronomical Society in National Harbor, Maryland.

The NICER work is a useful test of pulsar navigation under real flight conditions, says John Pye, manager of the Space Research Centre at the University of Leicester, UK, who has worked on the idea.

STELLAR BEACONS

Pulsars are the spinning, ultra-dense leftovers of exploded stars. Some emit radiation blasts as often as every few thousandths of a second. For decades, aerospace engineers have dreamed of using these consistently repeating signals for navigation, just as they use the regular ticking of atomic clocks on satellites for GPS.

In 1999–2000, the US Naval Research Laboratory flew a satellite experiment that showed that, in theory, spacecraft could orient themselves using pulsars. The European Space Agency has explored the concept in recent years, with researchers calculating that a spacecraft could use pulsars to locate itself with a margin of error of 2 kilometres, even when flying 30 times farther from Earth than Earth is from the Sun (S. Shemar *et al. Exp. Astron.* **42,** 101–138; 2016).

In November 2016, China launched an experimental pulsar-navigation satellite, called XPNAV-1. It studied the Crab pulsar, 2,000 parsecs (6,500 light-years) away in the constellation Taurus, as an early test of whether it could lock onto X-ray signals (X. Zhang *et al. Int. J. Aerosp. Eng.* **2017,** 8561830; 2017).

NICER was installed on the International Space Station in June 2017. Its main job is to measure the size of pulsars to improve scientists' understanding of the ultra-dense matter that makes up these dead stars. The pulsar-navigation experiment, known as the Station Explorer for X-ray Timing and Navigation Technology (SEXTANT), is a bonus.

"We think it's a big deal."

SEXTANT timed X-ray flashes coming from five pulsars, one of which is the closest and brightest known millisecond pulsar. The mission watched each of the beacons for about 5–15 minutes before swivelling autonomously to look at the next. By measuring tiny changes in the signals' arrival times as the experiment orbited Earth, NICER could independently calculate its own position in space.

Without pulsar navigation, spacecraft must communicate with Earth regularly to confirm their position. But such communication — through systems such as NASA's Deep Space Network, a group of giant satellite dishes — is time-consuming, expensive and more difficult the farther from Earth a probe travels. Pulsar navigation might work well for spacecraft in the outer Solar System because it could free probes to do many navigation-related tasks without waiting for instructions, says Gendreau.

FREEDOM TO ROAM

The technique could also provide an independent check on how well a spacecraft's conventional navigation systems are doing, says Zaven Arzoumanian, an astrophysicist at Goddard who is on the NICER team. NASA helped fund the test to see whether pulsars could be used as a back-up navigation method when its planned Orion crew capsule takes astronauts beyond low Earth orbit, some time in the 2020s.

NICER used 52 small X-ray telescopes for its study, but a single such telescope could probably do the job, Gendreau says. The instrument might weigh as little as 5 kilograms, making it relatively inexpensive to add to space missions, for which more mass means more money is needed for a launch.

The team plans to repeat the experiment in the coming months, hoping to reduce the margin of error to one kilometre or less. ■