BBC

THE ANIMALS WHOSE LIVES RELY ON THE NIGHT SKY

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Sky at Night

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HOW ALIENS WILL DETECT OUR TECH FROM SPACE

THE REAL ZODIAC: THE STARS BEHIND THE STAR SIGNS

China's spacecraft Tianwen-2 is scheduled to arrive at the asteroid Kamoʻoalewa in 2026

Tianwen-2

Unravelling the secrets of asteroids

China is set to mount the latest mission to retrieve a sample of an asteroid and bring it home. **Stuart Atkinson** investigates

Asteroids were once dismissed by astronomers as "the vermin of the skies", constantly getting in the way of more important observations. Not anymore. The former vermin have become one of the hottest areas of space research. Asteroids can reveal the history of our Solar System and offer a tantalising wealth of metals and minerals, not to mention their importance as a threat to our very existence on this planet. This month, China prepares to join in the quest to understand these space rocks with the launch of its most complex planetary mission to date, Tianwen-2. The spacecraft aims to visit not one but two asteroids, returning a fragment of one to Earth and cementing the nation's place as a major player in space exploration.

Cosmic time capsules

The mission is the latest step in a long journey of learning about these space rocks, which began with the discovery of the first asteroid, Ceres, by the astronomer Giuseppe Piazzi on 1 January 1801. Today, we know the positions and orbits of many thousands of asteroids with great accuracy and more are being found all the time. Around the world, survey telescopes are taking images of the sky, finding asteroids and tracking their orbits around the Sun, some of which pass perilously close to Earth. Eyebrows were raised in genuine concern earlier this year when an asteroid was found that, at first glance, had a small ▶

ILLUSTRATION: GETTY X2

Asteroids teach us about the origins of our Solar System and life on Earth – they're also a potential threat to our planet

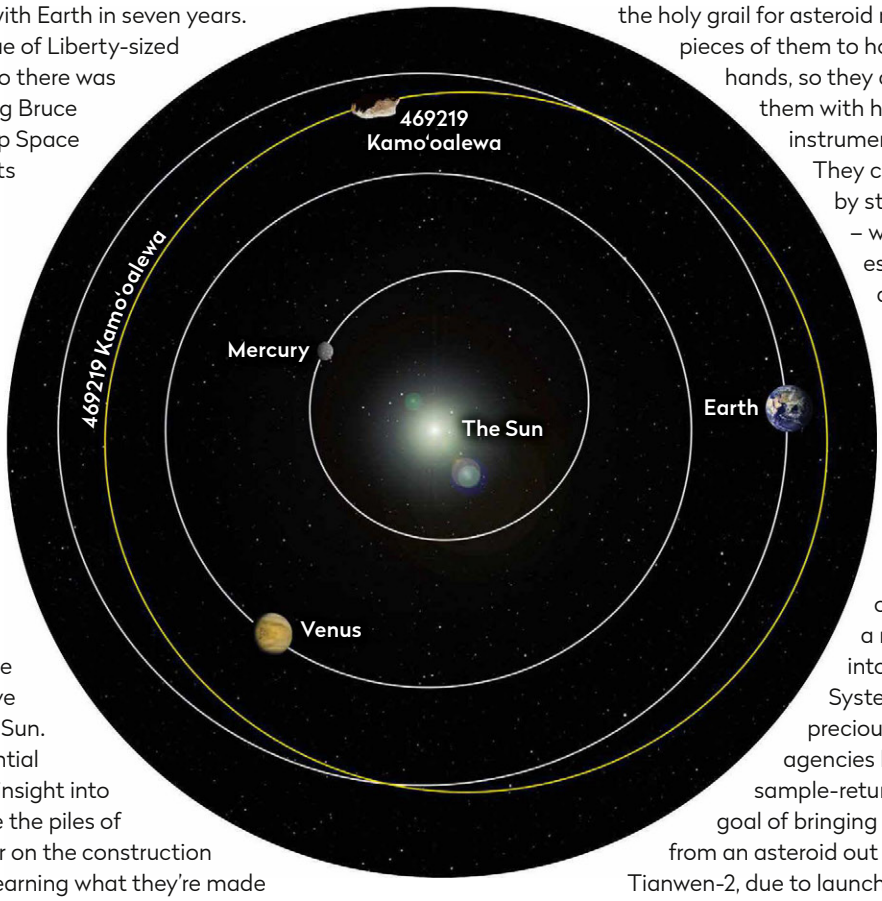
ILLUSTRATION

▶ chance of colliding with Earth in seven years. Luckily for us, the Statue of Liberty-sized 2024 YR4 will miss us, so there was no need to start training Bruce Willis to fly a souped-up Space Shuttle with a nuke in its payload bays.

We won't always be so lucky, and YR4 served as a timely reminder that one day astronomers will find an asteroid on a direct collision course with our planet. When that happens, we'll need a way of either deflecting or destroying it, which means knowing as much about asteroids as possible: what they're made of, how they move and how they orbit the Sun. But as well as our potential end, asteroids offer an insight into our beginning. They are the piles of builder's rubble left over on the construction site of the planets, so learning what they're made of and how they're put together helps us understand the processes that gave birth to the Solar System.

Ingredients of the Solar System

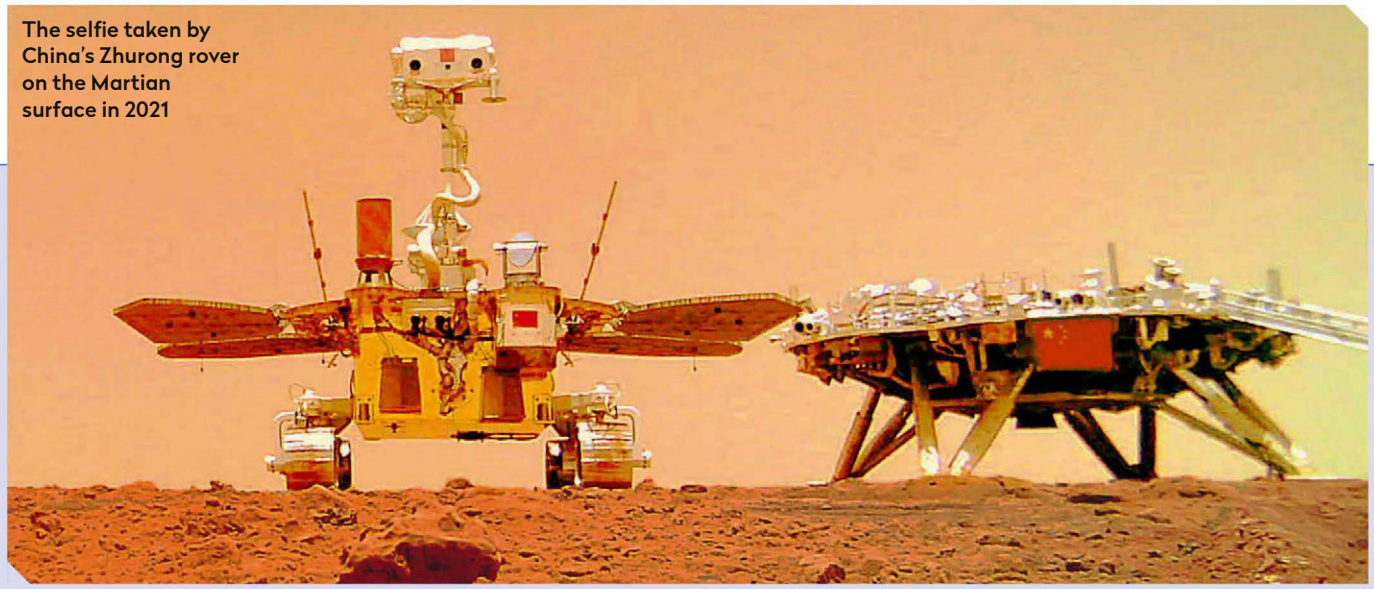
There have been many missions to these wandering space rocks. Some merely snapped a few images on their way elsewhere, while others were dedicated missions to examine specific asteroids. Ultimately, the holy grail for asteroid researchers is having pieces of them to hold in their gloved hands, so they can interrogate them with high-tech scientific instruments here on Earth. They can do this to a degree by studying meteorites – which are, after all, essentially pieces of asteroid that have landed on Earth – but these have been contaminated by our planet's weather and environment. What scientists want is a pristine sample, unchanged for billions of years, giving them a much greater insight into the past of the Solar System itself. To fetch these precious payloads, space agencies have mounted several sample-return missions, with the goal of bringing back a small piece from an asteroid out in space.



▲ **The Earth-like orbit of Tianwen-2's target, the asteroid Kamo'oalewa**

Tianwen-2, due to launch this month, is such a mission and the latest in a long line of increasingly ambitious Chinese space exploration projects. The mission has multiple aims, but its primary goal is to rendezvous with and then collect samples from the near-Earth asteroid 2016 HO3, also known as 469219 Kamo'oalewa. The Tianwen-2 team chose this asteroid because it is a 'quasi-satellite' of Earth, meaning it orbits the Sun on a path similar to Earth's

MIKDAM/GETTY, XINHUA/ALAMY STOCK PHOTO, NASA, NASA/GSFC/ARIZONA STATE UNIVERSITY



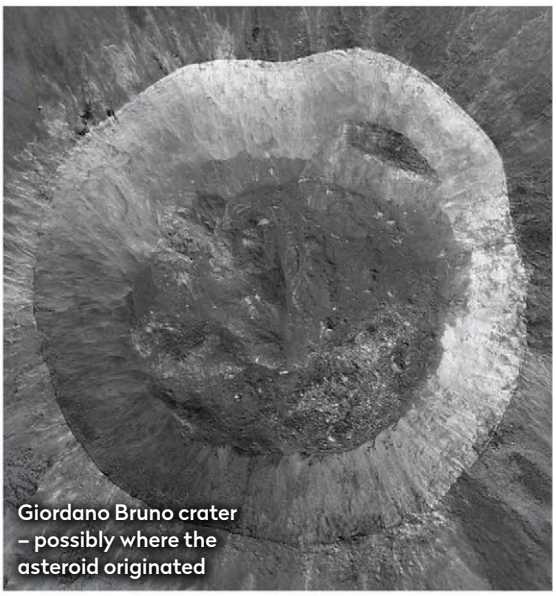
The selfie taken by China's Zhurong rover on the Martian surface in 2021

China's planetary ambitions

The nation is becoming an increasingly important space power

After years in NASA's shadow and perhaps not being taken entirely seriously by some, the Chinese space programme is now advancing relentlessly. While China likes to keep its cards close to its chest when it comes to its space endeavours, we do know it has ambitious goals. Two Chinese Yutu rovers have trundled across the Moon and their Zhurong rover has driven across the rust-hued plains of Mars. Soon after landing, Zhurong even took a 'selfie' with a small camera it dropped onto the ground, striking a cheeky, head-tilted pose. China now has its own space station with a modular design like the ISS. Tiangong now has four modules, multiple solar arrays, docking ports and a robot arm. Its taikonauts are conducting exciting scientific research and learning a lot about living in space for long periods, in preparation for their next giant leap: to the Moon. China's goal is to land people on the Moon "by 2030". They have already designed the rocket and spacecraft they'll use and the spacesuits too. They also have well-developed follow-on plans for lunar habitat modules, power plants and rovers to support a permanent presence on the Moon. Meanwhile, NASA's Artemis programme has been plagued by so many delays that many experts believe China could land people on the Moon before NASA does. Perhaps when the Artemis III astronauts do eventually land, they will find Chinese taikonauts waiting there to greet them.

▲ Kamo'oalewa's spectrum seems to match Moon rocks brought back by Apollo 14



Giordano Bruno crater – possibly where the asteroid originated

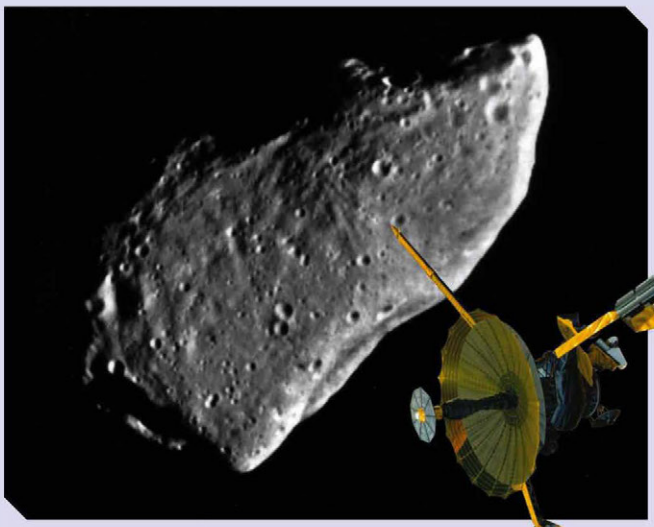
and even seemingly went into orbit around our planet for a few months in 2024. There's even a chance it could one day strike Earth; at 40–100 metres across, it would be large enough to take out a city – but that won't happen for at least another 100 million years.

What is Kamo'oalewa?

Ahead of the mission, astronomers have been studying the asteroid in detail to learn what they can from here on Earth. Kamo'oalewa seems to have a similar light fingerprint, or spectrum, to lunar rocks brought back by Apollo 14. This has led to theories that the asteroid may in fact be a lump of Moon rock ejected by another, much larger, asteroid striking the surface. The most likely candidate is the impact which created the 22km-wide (14 miles) Giordano Bruno crater on the lunar far side four million years ago. Another study examined how the Sun affects the orbit of the asteroid, both via the gentle push of the solar wind and as a side effect of sunlight heating the rock, known as the Yarkovsky effect. Understanding how these impact an asteroid's path ▶

Seven major asteroid missions

Previous spacecraft that have paid a visit to an asteroid



△ Galileo

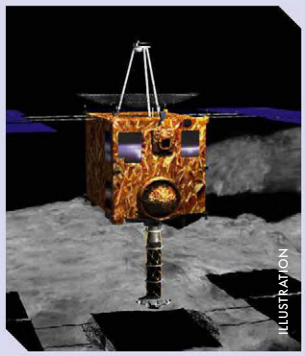
This NASA mission, primarily aimed at studying Jupiter (and now infamous for the failure of its primary communications antenna dish to unfurl properly) encountered two asteroids: Gaspra in 1991 and Ida in 1993. The probe flew past the asteroids without stopping but provided fascinating images and very valuable data about their surfaces and composition.

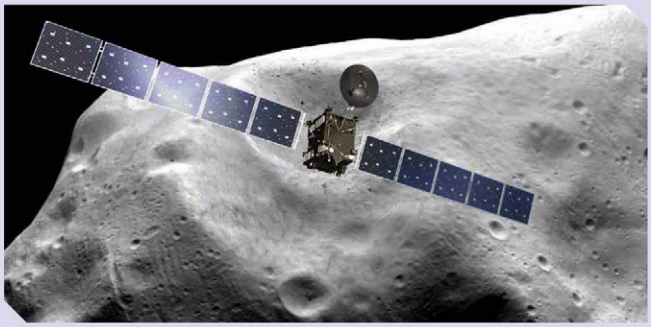
NEAR Shoemaker ▷

Launched in 1996, this history-making NASA mission, named after scientist Gene Shoemaker, was the first to orbit and land on an asteroid. In 2001, it touched down on the saddle-shaped asteroid 433 Eros, not only sending back incredibly detailed images of the craters on its surface but detailed information about its structure too.

Hayabusa ▷

This Japanese mission, launched in 2003, visited the asteroid Itokawa in 2005 with the aim of returning a sample of space rock to Earth. While en route, Hayabusa was struck by the largest solar flare in recorded history. Despite this, it successfully collected a sample and even returned it to Earth in 2010 – though the final sample was less than 1g.





△ Rosetta

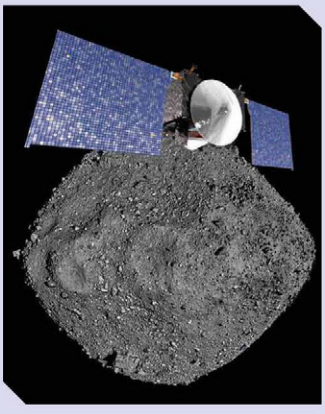
Before going into orbit around comet 67P/Churyumov–Gerasimenko and dropping a small lander onto its dusty surface, this hugely ambitious European Space Agency probe flew by two asteroids, Šteins in 2008 and Lutetia in 2010, capturing detailed images and data before continuing to its cometary close encounter.

△ Hayabusa2

Japan's space agency launched its second run at an asteroid sample-return mission in 2014, reaching near-Earth asteroid Ryugu in 2018. For the next year and a half, it surveyed the asteroid and collected samples that it brought back to Earth in December 2020. It also deployed four small rovers on the asteroid which had their own cameras and instruments.

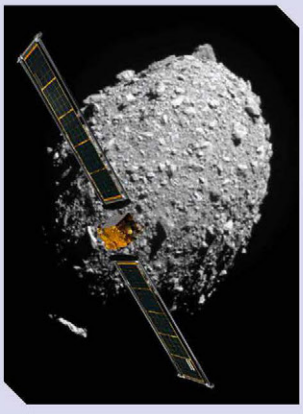
OSIRIS-REx ▷

Launched in 2016, OSIRIS-REx arrived at the near-Earth asteroid Bennu four years later and collected samples that returned to Earth via a capsule in 2023. They included black rocks, stones and dust, precious samples that are now being studied all around the world. The craft is now on a new mission to the asteroid Apophis and has hence been rechristened OSIRIS-APEX.



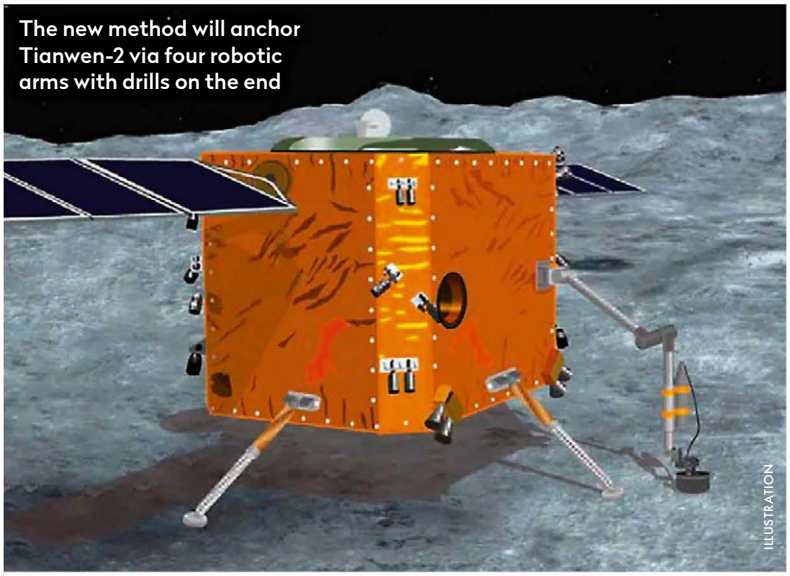
DART ▷

In 2022, NASA's Double Asteroid Redirection Test (DART) mission rendezvoused with the asteroid Didymos, but instead of simply studying it, the probe deliberately crashed into its moonlet, Dimorphos. This was to test the feasibility of deflecting an asteroid which might threaten Earth in the future – and it succeeded, shortening the moonlet's orbit around its parent asteroid by more than 30 minutes.



NASA X 3, JSC, JAXA, ESA 2010 MPS FOR OSIRIS TEAM MPS/UPD/LAM/IAA/RSSD/INTA/UPM/DASP/IDA, JAXA/AKIHIRO IKESHITA, NASA/JOHNS HOPKINS APL, NASA/GODDARD/UNIVERSITY OF ARIZONA, TAO ZHANG/KUN XU AND XILUN DING/NATURE ASTRONOMY, NASA/ESA AND D. JEWITT

◀ Bite the dust: OSIRIS-REx used a touch-and-go method to briefly land and snatch a sample of Bennu



The new method will anchor Tianwen-2 via four robotic arms with drills on the end

ILLUSTRATION

After Kamo'oalewa, Tianwen-2 will visit the six-tailed asteroid 311P/PanSTARRS

"Tianwen-2 will have a significant challenge as the asteroid Kamo'oalewa rotates once every 27 minutes"

▶ will allow astronomers to better predict their orbits. In both cases, Tianwen-2 will be able to deliver even more insight when it arrives at the asteroid in 2026.

How to grab an asteroid

When it comes to collecting the sample, Tianwen-2 will have a significant challenge as the asteroid rotates once every 27 minutes – the fastest rotation any such mission has faced. The spacecraft will trial two methods of collecting the precious asteroid dust.

The first will be to use the same 'touch-and-go' method of collecting asteroid dust as employed by previous sample-return missions Hayabusa2 and OSIRIS-REx, where the craft will only briefly approach the surface to snatch the sample. The second will be the first-ever attempt at an 'anchor-and-attach' acquisition. This is a much more complex manoeuvre, requiring the spacecraft to autonomously approach the asteroid, assess the landscape and then fix itself to the surface.

This will allow the spacecraft to make a much more controlled collection using a mechanical arm.

Stuart Atkinson is a lifelong amateur astronomer and author of 11 books on astronomy and spaceflight

Once collected, those samples will be safely stowed in a capsule and dispatched back to Earth in 2027, roughly two and half years after launch.

But its mission still won't be finished. Once it is done at Kamo'oalewa, the orbiter will then depart from the asteroid and set off on another journey to explore an active asteroid named 311P/PanSTARRS. This unusual object has the characteristics of both an asteroid and a comet, essentially offering a 'two-for-one' target that will give valuable insights into the composition and evolution of small celestial bodies.

Tianwen-2 (*tianwen* meaning 'questions to the heavens') is named after an ancient Chinese poem symbolising the quest for knowledge – very fitting, as it's now clear that the Chinese space programme is engaged in an exciting quest to explore the Solar System and gather as much knowledge as possible. Hopefully, the samples Tianwen-2 collects from its asteroid target will not only increase our understanding of asteroids but also help us prepare better for when we find ourselves in the cosmic crosshairs of one heading our way.