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Space invaders

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The truth is out there

Why are we here? Are we alone in the universe? Profound questions such as these are as old as astronomy itself, yet extremely relevant today. Dave Hall looks at the latest attempts by astronomers to understand our greatest cosmic enigmas

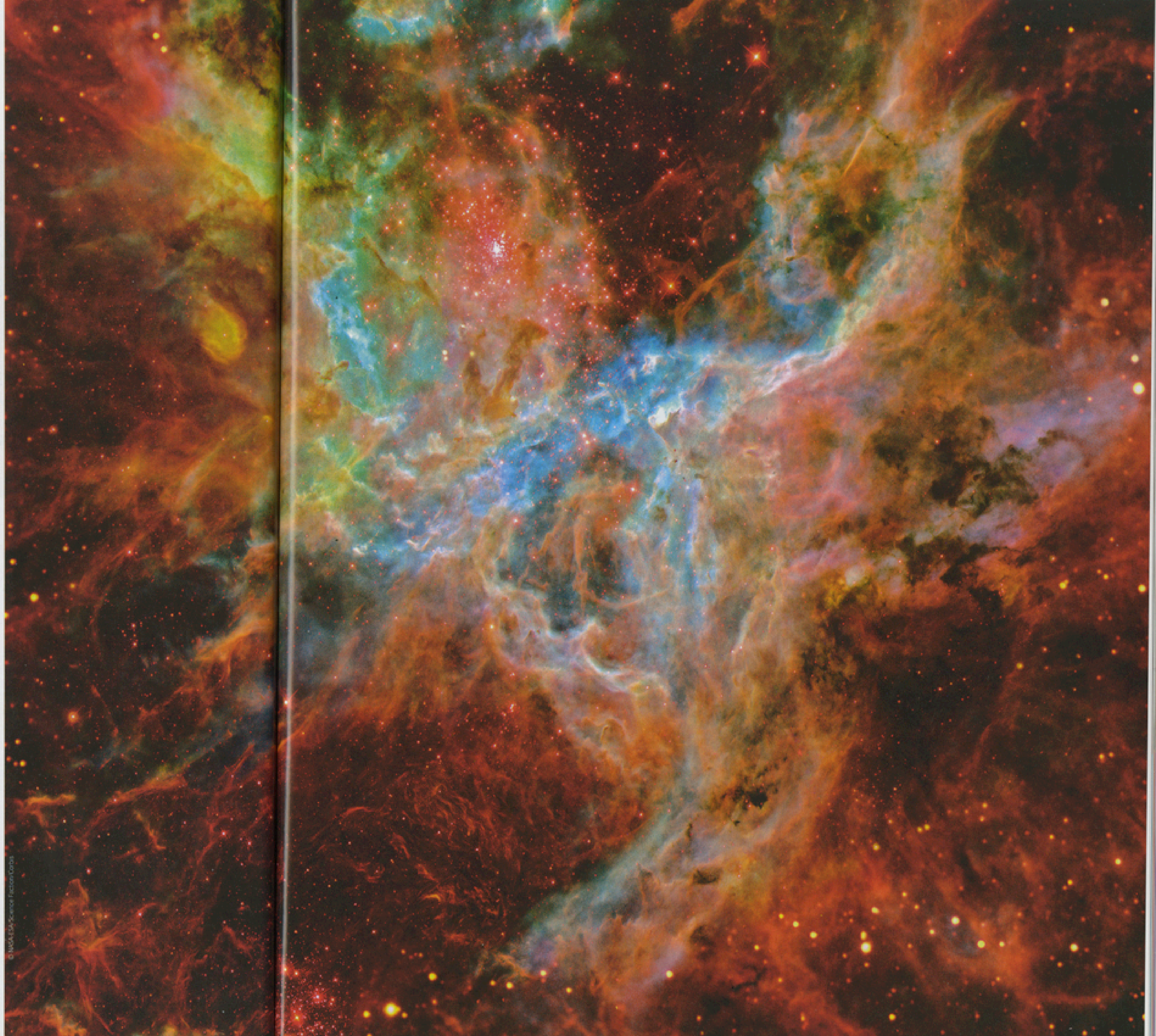
'The universe is not only stranger than we imagine, it's stranger than we *can* imagine.' So said the great scientist JBS Haldane in 1927. And the more we study it, the stranger it appears. Astronomers in the UK today, armed with an unprecedented arsenal of hi-tech equipment, are discovering new secrets about our universe at a heady rate. Yet their discoveries only reveal more tantalising questions.

Astronomy has the distinction of being the 'second oldest profession', according to the Royal Astronomical Society. There is much ancient evidence that proves it: 3,000 years ago, the Mayan astronomical calendar was able to predict eclipses and the movement of planets to an accuracy of one day every 6,000 years.

A wealth of astronomical knowledge has been handed down through the ages, from the Mesopotamians, the Egyptians, the Greeks and the Romans. Without it, there would have been no scientific revolution in the 16th and 17th centuries, when Copernicus, and later Galileo, dared to say the earth was not the centre of the universe after all. The advancement of science has continued apace ever since – through Newton's theory of gravity and Einstein's theory of relativity – to create modern mind-bending concepts such as quarks, quasars and the Big Bang.

Right now, astronomy is enjoying a boom in both branches of astronomy: the observational (recording what's out there) and the theoretical (explaining and predicting what's out there). This is partly thanks to technology. Where once observations were done with an earth-based optical telescope and a lot of patience, international radio telescopes now scan signals across the spectrum from radio waves to x-rays. Space telescopes such as Herschel and Hubble are now able to look into the very beginning of time.

Dr Tim O'Brien, reader in astronomy at the University of Manchester's Jodrell Bank Centre for Astrophysics, says the biggest changes have been in 'larger telescopes, which allow us to see further into space or investigate a new part of the spectrum'. Communications have also been key. 'When I got my PhD in 1988, there was no global



Right
The Tarantula Nebula – the largest known stellar nursery, located a mere 170,000 light years away

internet,' says O'Brien. 'Now it's far easier, as most modern research projects are massive international collaborative efforts.'

Watch this space

Several high-profile space missions are either under way or planned for the very near future. Among these is the Messenger (MErcury Surface, Space ENvironment, GEochemistry and Ranging) mission to Mercury, which has now entered its most intriguing phase. As the spacecraft swings into orbit around the innermost planet of our solar system, it should finally reveal in detail what is really going on the surface of our tiny cousin – a planet of extremes where the temperature routinely swings from a chilly -300C to a rather more balmy 600C at noon.

The European Space Agency's (ESA) Planck observatory launched in May 2009, is currently sitting at Lagrangian point 2 (L2) – a lonely gravitational equilibrium about 1 million miles in the opposite direction from the sun. There it detects radio waves set off just after the Big Bang – the oldest light in the universe.

'Planck will give us the best ever view of this cosmic microwave background,' says O'Brien. 'We'll be able to see what conditions were like before the first stars and galaxies, and the results will be available in 2013. We are very excited about it.'

Planck's companion, perched atop an Ariane rocket, was the Herschel infrared telescope, which, according to the ESA, 'marks the beginning of a new generation of space giants'. The largest space telescope of its kind, it too sits at L2 and collects infrared radiation from objects too cool or dark to be seen with visible light. Its data, which will help us discover how galaxies formed, is already giving astronomers amazing results, such as the most detailed image ever taken of that particularly fertile star-nursery, the Andromeda galaxy.

© SSPL/Getty Images

Above
Pages from Galileo's *Sidereus Nuncius* or *Starry Messenger* (1610), a seminal book of astronomical theory and observation

The imminent launch of NASA's James Webb Space Telescope is another project that is exciting researchers and academics. In 2014, it will replace the faithful servant Hubble, which since 1990 has been bringing us images of the universe as it was 13 billion years ago.

Back on the ground and closer to home, UK postgraduate research is beginning to reap the benefits from the new e-Merlin telescope array – a network of seven telescopes, spread almost 220km apart, connected by hi-tech fibre optics to Jodrell Bank. Together, they act as a super-powerful zoom-lens that allows a detailed study of objects out towards the edge of the observable universe.

Wobbles, winks and blips

Despite all this excitement, the big area for research at the moment is the search for exoplanets – planets that orbit other suns. Since 1992, about 1,200 have been discovered. Three methods have proven successful to find these elusive objects: wobbles, winks, and blips, as astronomers call them. The wobble is the minute gravitational effect of a planet on its parent star; the wink is the tiny dip in a star's light caused by a planet passing in front; and a blip is rather more complicated. Mass curves light, as Einstein predicted, and when distant stars line up, the light from the background star bends round the star in front, magnifying the light from the background star. This is called gravitational microlensing. The gravity of a planet around the foreground star can lead to a further brief blip or dip.

By using such techniques, researchers, including Martin Dominik, Royal Society research fellow at the University of St Andrews, discovered in 2006 a 'super-Earth' about 20,000 light years away, near the centre of the Milky Way. 'We also found a half-scale lookalike of the solar system,' he says, 'which shows that, while it may not be the generic prototype of all planetary systems, our solar system is unlikely to be unique, and rather more likely to be one of many. Such discoveries allow us to put theories of planet formation and evolution to the test. Moreover, they define the place of planet Earth within its cosmic context.'

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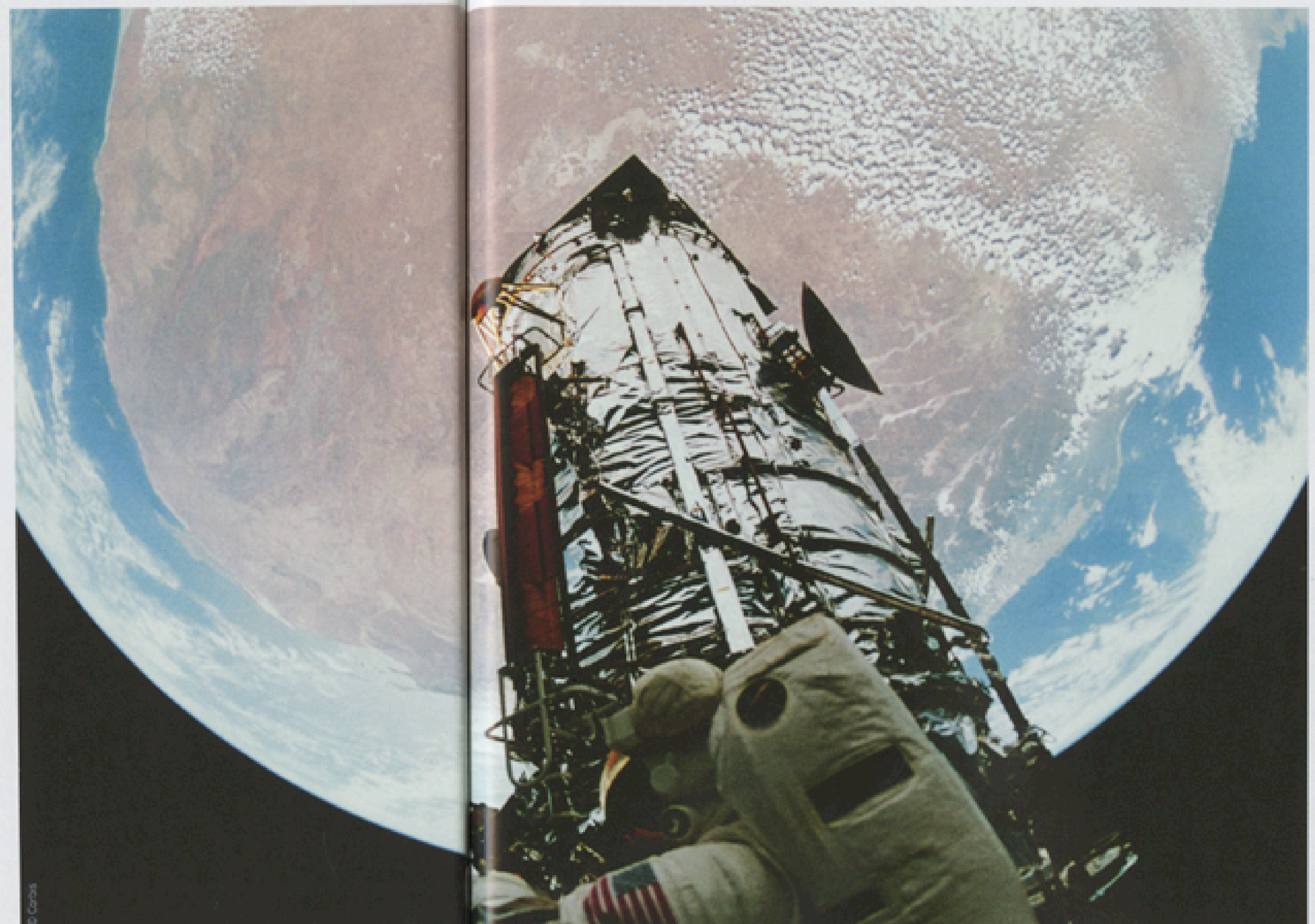

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Right
An astronaut repairs the Hubble Space Telescope, with Australia looming large in the background

Indeed, results from the Kepler space observatory, launched in March 2009, have led to estimates that there may be at least 50 billion planets in our own galaxy alone (one of 170 billion galaxies in the observable universe). Even more incredibly, technology has made it possible to analyse the atmosphere on these exoplanets, says O'Brien. 'Starlight reaches us via the atmosphere of the planet, and from spectral analysis we are able to work out what the atmosphere's made of. This means that, in the future, we might be able to tell whether there is life on a distant planet,' he says. (See box on page 54.)

University of St Andrews astrobiologist Dr Jane Greaves is involved in the search for these exoplanets. 'Some of our postgraduates are working on calculating the probability of finding a habitable, Earth-like planet by working out the amount of raw material around stars, or trying to find out which existing exoplanets are in the so-called Goldilocks Zone,' she says. 'These are planets that are precisely the right distance away from their star in order for them to host liquid water – and therefore support life as we know it.'

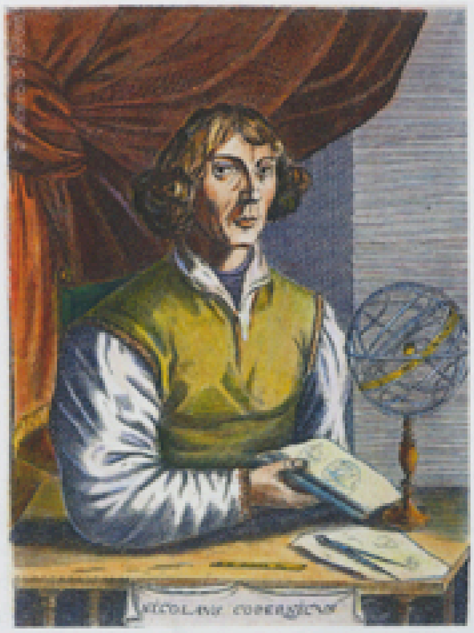
From the dark into the light

Encouragingly, the options for astrological postgraduate study in the UK are astoundingly varied. You could be researching planetary geology and geophysics, astrobiology, exploding stars, or searching for other planets. Or you could be digging deep into dark matter and particle physics just like PhD student Ryan Cooke. He left the sunny Gold Coast of Australia for a place at the Institute of Astronomy at the University of Cambridge, where he is studying the properties of the first stars in our universe. 'What I'm really interested in are the objects that brought the universe out of its dark ages,' he says. 'This was a period when the universe was dark and cold – nothing had yet formed into anything that we can imagine

Right
Artist's impression of the James Webb Space Telescope, an infrared telescope due to launch in 2013. It will observe the most distant objects in the universe

today. These objects are the final frontier of observational astronomy.' Cooke says that for him and his fellow PhD students, these are interesting times. 'Ongoing space-based missions such as Planck and Herschel, as well as the scheduled launch of the James Webb Space Telescope, will revolutionise astronomy. We might discover entirely new objects and look at the first stars directly for the first time.'

Part of the attraction of coming to do research in the UK is its scientific community. In astronomy, this is a legacy that dates back to Isaac Newton and has been pushed forward by leading lights such as Martin Rees and Stephen Hawking. Cooke, who has recently been working with former Royal Astronomical Society president Donald Lynden-Bell and, more recently, Herschel medallist Max Pettini, explains the attraction. 'You might ask why, as an astronomer, I would come to a country where I can't see the skies!' he says. 'But I've been here two-and-a-half years now and it's such a stimulating research environment.'



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16th-century astronomer and mathematician Copernicus, whose *On the Revolutions of the Celestial Spheres* (1543) is often regarded as the starting point of modern astronomy

In simple terms, astronomy thrives across the UK – but crucially looks beyond its borders. At the University of Edinburgh, for instance, your MSc in Astronomy could see you jetting off to use facilities in Hawaii, La Palma or Australia to research the evolution of galaxies and quasars. There are also UK-wide opportunities to join teams developing the UK's infrared and millimetre telescopes.

The next frontier?

Although competition for careers in academic astronomy is fierce, the Royal Astronomical Society says that between one third and half of astronomy PhD students in the UK can expect a post-doctoral appointment at the end of their studies, either in the UK or elsewhere. It also points out that skills such as teaching and IT learned during an astronomy PhD are transferable assets.

The normally sceptical Colin Pillinger, recently of the Open University and the ESA's 2003 Beagle mission, says students can always get into commercial space engineering – 'one of the few industries least hit by the downturn, which means students should still be encouraged to study astronomy'. At Jodrell Bank, a new course has been launched to tie in with this trend. 'We are offering a new MSc in radio imaging and sensing,' explains O'Brien. 'It also has a multitude of terrestrial applications, such as security technology.'

Of course, one could simply study astronomy for its own sake. 'People sometimes ask me, what with so many problems at home, why do we look at the sky?' says Dominik. 'But imagine what we could learn about our own planet by studying other worlds.' Strange though the universe may seem, our knowledge of what's out there grows on a daily basis. Might we discover something strangely familiar? 'Our solar system is one of many like ours – and unlike ours,' says Dominik. 'We may not be so special after all.' ■

The search for ET: unusual research

The Search for Extraterrestrial Intelligence (SETI) is the collective name for the vast array of attempts people have made over the years to capture that elusive signal from ET. Professionals and amateurs alike have spent more than 50 years scanning the sky without success. If we did finally make contact, what would the impact be?

'Depending on what kind of life forms are detected and where they are, the impact could be pretty severe,' said University of St Andrews Royal Society research fellow Martin Dominik. He was speaking at a January 2010 symposium he co-chaired with Open University professor John Zarnecki, entitled The detection of extraterrestrial life and the consequences for science and society.

Open University astronomer Colin Pillinger agreed. 'If we could show that life on Earth is not unique, the discovery would be on a par with Copernicus saying the Earth went round the sun,' he said. 'It would be a fundamental shift in the way we think about ourselves.'

In the meantime, the search for exoplanets goes on. But how long will it be until we find another Earth? 'Soon,' says Dr Tim O'Brien, reader in astronomy at the University of Manchester's Jodrell Bank Centre for Astrophysics. 'They are hard to find, but it could be just weeks or months.' Dominik agrees: 'A planet of similar mass, size and temperature could be found at any moment. That won't tell us whether there is life on it or not, but we might be able to find out.'

Dominik's colleague Dr Jane Greaves is more cautious. 'It is hard to say when we might detect a planet like Earth. And when we do, it could take some time to be able to say anything about its atmosphere. Just having oxygen is not sufficient evidence for life. The Earth had plenty of oxygen in its early life, but it was a million years before photosynthesis began to occur. So the big goal in the next few years is to detect these biosigns.' That, she says, would demand even bigger telescopes.

Simon Conway Morris, professor of evolutionary palaeobiology at Cambridge University, believes we should prepare for the worst. If evolution behaves the same on alien worlds, he says, it may produce beings with the same competitive attributes as ourselves – perhaps worse. Either that, or we are completely alone. 'So which is worse,' he ponders. 'Meeting ourselves – or meeting nobody?'