Finding things in the dark

One more trick has been added in the quest for exoplanets, says s ananthanarayanan

PLANETS orbiting distant suns can never be seen because they only reflect the light of parent stars and, at a distance of several light years, cannot be made out in the glare of their respective stars. Exoplanets are thus detected by indirect means. The first indirect method, which works for large planets, uses a slight wobble of the parent star, which the planet induces as it goes round in its orbit. The back-and-forth movement of the star causes variations in the frequency, which is the colour of the starlight that reaches the earth and these changes can be detected. By measuring the colour shift, the speed and extent of a star's wobble the nature of the unseen planet can be worked out. This works best for large planets because small planets, whose size compares with earth, do not cause appreciable wobble.

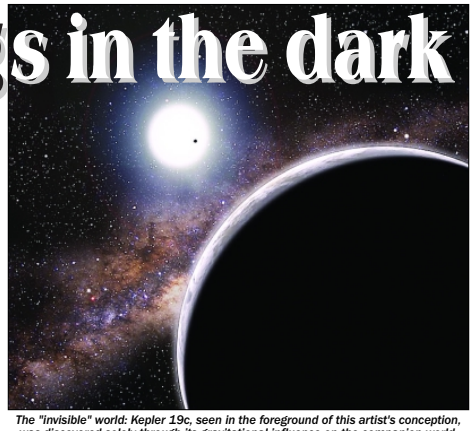
The other method uses a slight dip in the amount of light that comes to earth from the star, when the exoplanet passes in front of the star. The instruments that astronomers use are now sensitive enough to measure minute changes in the intensity of light and it is possible to use this method to detect even earth-sized planets, which is the kind we are most interested in. The National Aeronautics and Space Administration's *Kepler project* is a space-based – and orbiting telescope launched in 2009 to carry out this work most efficiently from a place that is outside the distortion that comes from earth's atmosphere. The telescope is about a metre in diameter and its light measuring arrangement is sensitive to one-hundredth of a per cent, which amounts to measuring the dip in intensity of a car headlight when a fruitfly goes past.

This way of detecting exoplanets also reveals the size of the planet, from the extent of light dimming and the nature of the orbit, from the "time of transit". But we can see that this method can be used only when the exoplanet transits the star along the line from the star to the earth. If the orbit is in a different plane, is will not block the light that reaches earth and there is no "transit". Such a planet would thus be "invisible". While hundreds of exoplanets have been found using the method of "transits", astronomers are conscious that they have found only a fraction of the planets that are there, waiting to be detected, but cannot be found by this method.

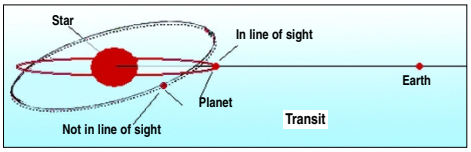
Finding the invisible

Sarah Ballard and others at the Harvard-Smithsonian Centre for Astrophysics report in a paper soon to appear in *The Astrophysical Journal* that they have used the data from Kepler to work out the presence of an exoplanet that does not appear in "transits". The method they used relies on the fact that the invisible planet, which does not pass before the star, still affects the motion of a sister planet that does.

The star whose system was being studied is *Kepler 19*, a star in the constellation *Lyra*, 650 light years away. Its planet, *Kepler 19b*, is a world about twice as large as earth and orbits its sun every nine days and seven hours. As expected for such a fast speed of orbit, it is only some 15 million km away from its sun, unlike earth, which is over 150 million km away. And because it is so near the star, it heats up to a scorching 500? Celsius. But the interesting thing about Kepler 19b is that its time of orbit does not stay constant and keeps getting five minutes shorter or longer — the planet seems to speed up or slow down!



The "invisible" world: Kepler 19c, seen in the foreground of this artist's conception, was discovered solely through its gravitational influence on the companion world, Kepler 19b – the dot crossing the star's face. Kepler 19b is slightly more than twice the diameter of earth and is probably a "mini-Neptune". Nothing is known about Kepler 19c other than that it exists.



Sarah Ballard

David Charbonneau

Now one of the great constants that we are used to is the time of revolution of planets. Earth takes 365 and a quarter days to go round the sun and while there may be a gradual slowing, over millennia, there is no variation from year to year. The thing that could be causing the variations in the case of Kepler 19b has to be another planet, which moves so that its force of gravitation becomes strong maybe every two revolutions, to bring about this alternation in the period of Kepler 19b. This other planet, yet unseen, has been named Kepler 19c and its own period of revolution would also be uneven, being affected by the first planet. But as it has never been spotted, the orbit of Kepler 19c apparently does not cross the path between the star, Kepler 19 and earth.

It was this method of deducing a planet's presence that was first used back in 1846 to discover Neptune. Just four times the size of earth but 30 times further away from the sun, the planet is not visible to the naked eye and had not been sighted before. But there were variations in the orbit of Uranus, which led to the conclusion that there was a neighbouring planet whose gravitational force was causing the disturbance. Neptune was actually sighted, subsequently, at almost the very place that had been worked out theoretically.

But the data of only the variation in the period of Kepler 19b is not enough to tell us anything more about Kepler 19c, except that it exists. The orbit may be faster than Kepler 19b or it may be slower. It may be circular or it may be elliptical. The planet may be rocky or it may be a gas planet. As it does not affect the mother star to any appreciable extent, even its mass cannot be worked out. All we know is that it is there!

But the fact that it has been detected is to show that methods that worked in the solar system are equally good at the greatest distances and a picture of the unseen cosmos may still be drawn. "This method holds great promise for finding planets that can't be found otherwise," says Harvard astronomer and co-author, David Charbonneau.

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Oldest ancestor

South African 'apeman' could be a missing link, says steve connor

A PRIMITIVE species of "apeman" who lived about two million years ago has become the strongest candidate for being the oldest direct ancestor of the entire family of human species, from the earliest Homo erectus to the anatomically modern Homo sapiens of today. Exhaustive investigations of two partial skeletons of the primitive hominin — a young adult female and a male child of about 11 — have revealed that this extinct species possessed anatomical features unique to the human lineage.

Studies of the hominin's fossilised brain case, pelvis, hand and feet indicate that Australopithecus sediba, which was only formally identified 18 months ago, could turn out to be a crucial "missing link" that connects the human genus to the rest of the primate evolutionary tree.

Professor Lee Berger of the University of Witwatersand in Johannesburg, who discovered the fossils at the site of an ancient cave system at Malapa, 30 miles north-west of the South African city, said the analysis provides convincing evidence that A. sediba was the immediate direct ancestor of the human species. "The fossils demonstrate a surprisingly advanced but small brain, a very evolved hand with a long thumb like a human, a very modern pelvis, but a foot and ankle shape never seen in any hominin species that combines features of both apes and humans in one anatomical package," Professor Berger said. "The many very advanced features found in the brain and body, and the earlier date make it possibly the best candidate ancestor for our genus, the genus Homo, more so than previous discoveries," he added.

The hand of Australopithecus sediba is much smaller than that of modern man.

Dating of rock sediments stuck to the fossils have placed the age of the skeletons to between 1.977 million and 1.98 million years — one of the most accurate dating estimates for this period in hominin history. This in itself puts A. sediba in a prime position for being the ancestor of Homo, which emerged as a distinct genus relatively soon afterwards. The earliest accepted member of the human family tree is Homo erectus, a species that lived between about 1.8 million and 1.3 million years ago, left Africa and became widely dispersed in Asia. Earlier human species that lived in Africa, such as Homo habilis and Homo rudolfensis, which were dated to 1.9 million years ago, were considered ancestral to H. erectus, but some experts have questioned whether they are truly human.

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Coral reefs 'will be gone by end of the century'

They will be the first entire ecosystem to be destroyed by human activity. andrew marszal **reports**

CORAL reefs are on course to become the first ecosystem that human activity will eliminate entirely from earth, according to a leading United Nations scientist. He says this event will occur before the end of the present century, which means that there are children already born who will live to see a world without coral.

The claim is made in a recently published book which says coral reef ecosystems are very likely to disappear this century in what would be "a new first for mankind — the 'extinction' of an entire ecosystem". Its author, Professor Peter Sale, studied the Great Barrier Reef for 20 years at the University of Sydney. He currently leads a team at the United Nations University Institute for Water, Environment and Health.

The predicted decline is mainly down to climate change and ocean acidification, though local activities such as overfishing, pollution and coastal development have also harmed the reefs. The book, *Our Dying Planet*, published by University of California Press, contains further alarming predictions, such as the prospect that "we risk having no reefs that resemble those of today in as little as 30 or 40 more years".

Professor Sale says, "We're creating a situation where the organisms that make coral reefs are becoming so compromised by what we're doing that many of them are going to be extinct, and the others are going to be very, very rare. Because of that, they aren't going to be able to do the construction which leads to the phenomenon we call a reef. We've wiped out a lot of species over the years. This will be the first time we've actually eliminated an entire ecosystem."

Coral reefs are important for the immense biodiversity of their ecosystems. They contain a quarter of all marine species, despite covering only 0.1 per cent of the world's oceans by area, and are more diverse even than the rainforests in terms of diversity per acre, or types of different *phyla* present. Recent research into coral reefs' highly diverse and unique chemical composition has found many compounds useful to the medical industry, which could be lost if present trends persist. New means of tackling cancer developed from reef ecosystems have been announced in the past few months, including a radical new treatment for leukaemia derived from a reef-dwelling sponge. Another possible application of compounds found in coral as a powerful sunblock has also been mooted.

And coral reefs are of considerable economic value to humans, both as abundant fishing resources and — often more lucratively — as tourist destinations. About 850 million people live within 100 km of a reef, of which some 275 million are likely to depend on the reef ecosystems for nutrition or livelihood. Fringing reefs can also help to protect low-lying islands and coastal regions from extreme weather, absorbing waves before they reach vulnerable populations.

Carbon emissions generated by human activity, especially our heavy use of fossils fuels, are the biggest cause of the anticipated rapid decline, impacting on coral reefs in two main ways. Climate change increases ocean surface temperatures, which have already risen by 0.67° Celsius in the past century. This puts corals under enormous stress and leads to coral bleaching, where the photosynthesising algae on which the reef-building creatures depend for energy disappear. Deprived of these for even a few weeks, the corals die.

On top of this comes ocean acidification. Roughly one-third of the extra carbon dioxide we put into the atmosphere is absorbed through the ocean surface, acidifying shallower waters. A more recently recognised problem in tropical reef systems, the imbalance created makes it harder for reef organisms to retrieve the minerals needed to build their carbonaceous skeletons. "If they can't build their skeletons — or they have to put a lot more energy into building them relative to all the other things they need to do, like reproduce — it has a detrimental effect on the coral reefs," says Paul Johnston of the University of Exeter, and founder of the UK's Greenpeace Research Laboratories.

An important caveat to the book's predictions is that the corals themselves — the tiny organisms largely responsible for creating reefs — may be lucky enough to survive the destruction, if past mass extinction episodes are anything to go by. "Although corals are ancient animals and have been around for hundreds of millions of years, there have been periods of reefs, and periods where there are no reefs," explains Mark Spalding of the US-based environmental group, Nature Conservancy, and the University of Cambridge. "When climatic conditions are right they build these fantastic structures, but when they're not they wait in the wings, in little refuges, as a rather obscure invertebrate."

Australia's Great Barrier Reef is the planet's largest reef system and one of the seven natural wonders of the world, but it may not survive the century.

The gaps between periods in which reefs are present have been long even in geological terms, described in the book as "multimillion-year pauses". And reef disappearance has tended to precede wider mass extinction events, offering an ominous "canary in the environmental coal mine" for the present day, according to the author. "People have been talking about current biodiversity loss as the Holocene mass extinction, meaning that the losses of species that are occurring now are in every way equivalent to the mass extinctions of the past," Professor Sale says. "I think there is every possibility that is what we are seeing."

About 20 per cent of global coral reefs have already been lost in the past few decades. Mass bleaching events leading to widespread coral death are a relatively recent phenomenon; though scientists have been studying coral reefs in earnest since the 1950s, mass bleaching was first observed only in 1983. Dr Spalding, who witnessed the catastrophic 1998 mass bleaching in the Indian Ocean first hand, says, "It was a shocking wake-up call for the world of science, and a shocking wake-up for me to be actually there as we watched literally 80 to 90 per cent of all the corals die on the reefs of the Seychelles and other islands in a few weeks." That single event destroyed 16 per cent of the world's coral.

But according to the book's author, "The 1998 bleaching was spectacular because it was so extensive and so conspicuous. But there have been mass bleachings that have been global since then: 2005 was bad; 2010 was bad. The visual appearance is not nearly as severe as it was in 1998, simply because there is less coral around."

These dramatic episodes coincide with unusual weather patterns such as El Niño, but are increasing in severity and frequency due to climate change. As such, tackling global warming is the most urgent solution advocated by the book. "If we can keep CO2 concentrations below 450 parts per million we would be able to save something resembling coral reefs," Professor Sale says. "They wouldn't be the coral reefs of the 1950s or 1960s, but they would be recognisably coral reefs, and they would function as reefs." The current atmospheric carbon dioxide concentration is about 390 parts per million, but few experts believe it will remain below 500 for long.

There are signs that local conservation efforts can make a difference. Alex Rogers, professor of conservation biology at Oxford University, says, "We know for certain that corals subject to low levels of stress are much more able to recover. So if you take away pressures like overfishing of coral reefs and pollution, this has profound effects on recovery. But what we're really doing is buying time for many of these ecosystems. If climate change continues at its current rate, they will be done for eventually."

Though not all scientists agree with the precise timescales set out by the book, the crisis is clear. "When you're talking about the destruction of an entire ecosystem within one human generation, there might be some small differences in the details — it is a dramatic image and a dramatic statement," Professor Rogers says. "But the overall message we agree with. People are not taking on board the sheer speed of the changes we're seeing."

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