ALIEN INVADER

A world from another galaxy could change our ideas of how planets form

WORDS: PAUL SUTHERLAND

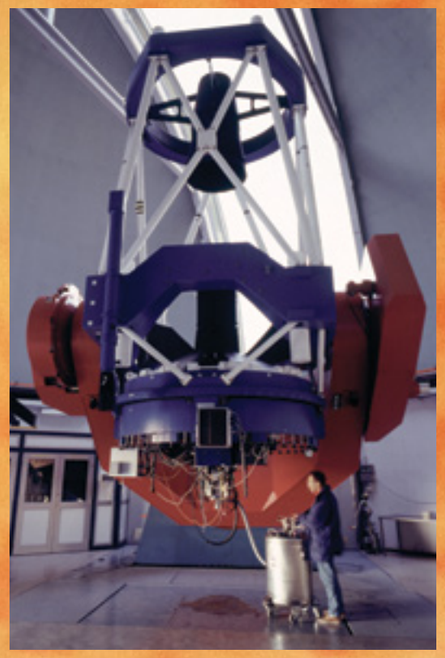
Two decades have passed since the first planets were discovered outside our own Solar System. Increasingly sophisticated techniques have helped astronomers to mop up more and more since, and today the tally of exoplanets stands at well over 500.

Amongst this great haul of planets, one stands out as being particularly peculiar. Lumbered with a typically uninspiring name, HIP 13044b is a so-called hot Jupiter that is around a quarter as massive again as our Solar System's largest planet. It was detected by a team led by Johny Setiawan, of the Max Planck Institute for Astronomy in Germany.

HIP 13044b is significant in many ways. First, this new world appears to belong to a star (HIP 13044) that 'invaded' the Milky Way from another galaxy. It's odd in another way too. It orbits a type of ageing star that has gone past the stage of being a red giant. A planet such as this might be expected to have been destroyed or swallowed up by its host star when it grew hugely in size to become a red giant, a fate that our Sun is also expected to undergo in around five billion years' time. HIP 13044 is said to be 'metal-poor', meaning that it contains very little of any elements other than hydrogen and helium. The mystery of how such a star could produce a planet when it lacks the heavier elements needed to build one is leading astronomers to re-examine their theories of how worlds form.

History of a star

HIP 13044b cannot be viewed directly, lying 2,300 lightyears away from us, but it revealed its existence through a technique called 'radial velocity'. Its host star, in the southern constellation of Fornax, was observed to wobble due to the gravitational tug exerted by its companion. The discovery observations were made with a high-resolution spectrograph called FEROS, which is attached to the 2.2m telescope at the European Southern Observatory at La Silla in Chile. The planet zips ▸



▲ The 2.2m telescope at La Silla that first revealed the existence of planet HIP 13044b

TIMOTHEOS SAMARTZIDI, ESO/H.H.HEYER

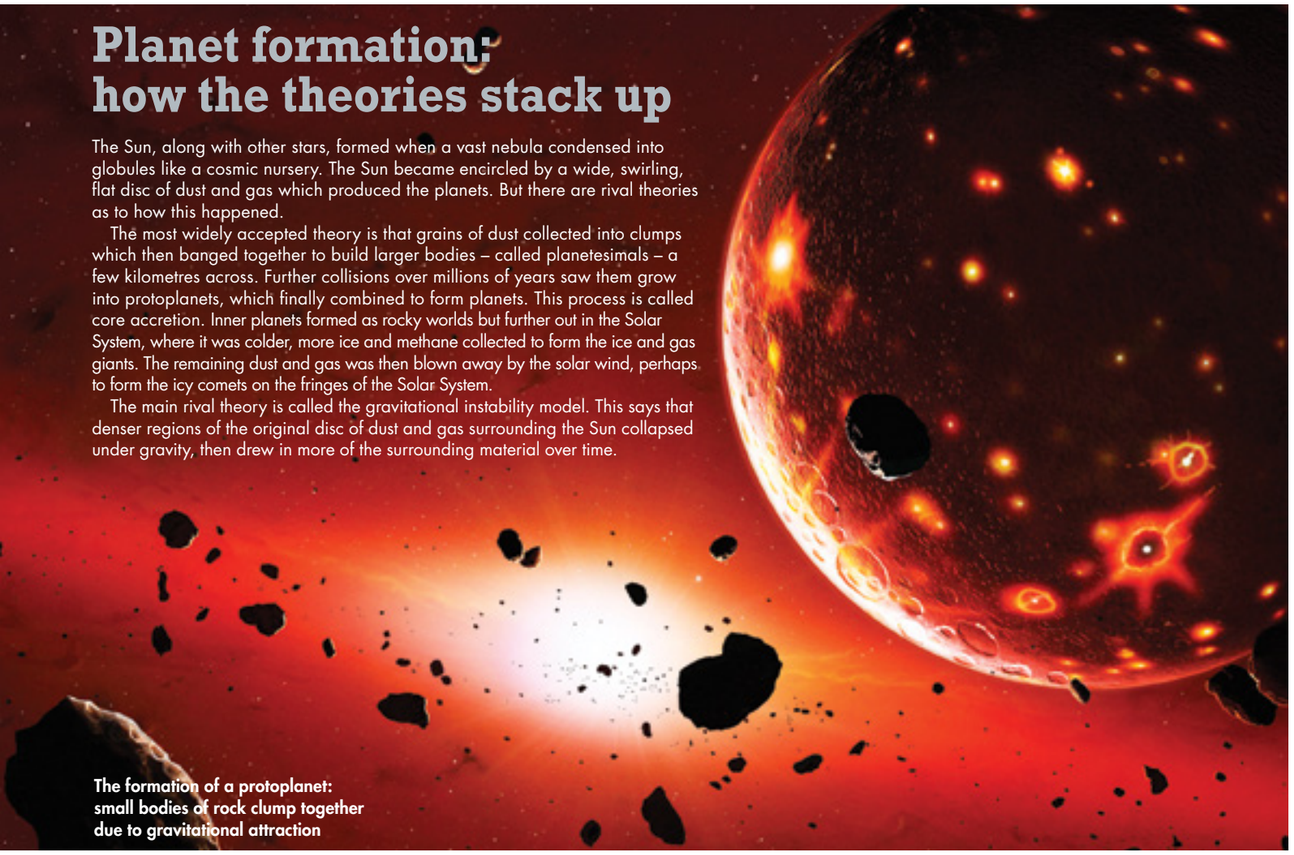
The Jupiter-like planet, HIP 13044b, orbits perilously close to its star, which threatens to engulf it

Planet formation: how the theories stack up

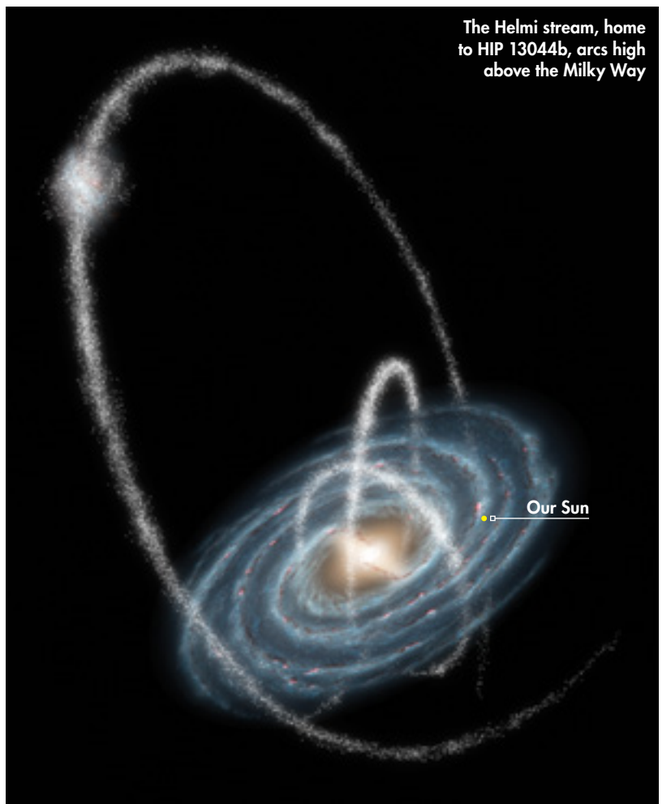
The Sun, along with other stars, formed when a vast nebula condensed into globules like a cosmic nursery. The Sun became encircled by a wide, swirling, flat disc of dust and gas which produced the planets. But there are rival theories as to how this happened.

The most widely accepted theory is that grains of dust collected into clumps which then banged together to build larger bodies – called planetesimals – a few kilometres across. Further collisions over millions of years saw them grow into protoplanets, which finally combined to form planets. This process is called core accretion. Inner planets formed as rocky worlds but further out in the Solar System, where it was colder, more ice and methane collected to form the ice and gas giants. The remaining dust and gas was then blown away by the solar wind, perhaps to form the icy comets on the fringes of the Solar System.

The main rival theory is called the gravitational instability model. This says that denser regions of the original disc of dust and gas surrounding the Sun collapsed under gravity, then drew in more of the surrounding material over time.



The formation of a protoplanet: small bodies of rock clump together due to gravitational attraction



The Helmi stream, home to HIP 13044b, arcs high above the Milky Way

MARK GARLICK/SCIENCE PHOTO LIBRARY X 2; NASA/JPL-CALTECH/R. HURT (SSC/CALTECH)

► around its star in just over 16 days at a distance of less than the star's own diameter from its surface.

Dr Setiawan's team was studying a group of stars in what is called the Helmi stream, which stretches above and below the general plane of the Milky Way. It is thought that this unusual pattern is due to these stars having been absorbed into our own Galaxy six to nine billion years ago from a separate dwarf galaxy that was once a satellite or neighbour of our own.

If the new planet's host star is so old and unsuitable for planets, you might wonder why Dr Setiawan and his colleagues were looking at it in the first place. But he believes it is important to examine stars at all stages in their lives.

"I'm not just looking for new planets," says Dr Setiawan, "I'm interested in how the Solar System or other planetary systems evolve, to find a sort of history of the life of stars and their planets. To do that, we have to look at stars that are not like the Sun, and we have to search for planets around stars different from the Sun."

Dr Setiawan continues: "It's similar to producing a photo album for your own family. You want to have pictures of the grandfather and the parents and the children and so on. We are trying to find stars that are older than the Sun and to understand if these stars can also have a planet, or the remains of a planet if it has already been engulfed or destroyed."

To begin with, the star was Sun-like and its planet was a regular Jupiter-like world. Just like Jupiter in our own Solar System, it was several Astronomical Units away from the star. But when the star evolved and became a giant, the planet must have spiralled in towards it.

As Setiawan explains, finding a planet wasn't even the most interesting part of the research. After all, more than 500 exoplanets have been discovered. Instead, the most fascinating aspect was the fact that the star has passed the red giant stage, growing so big that a planet should simply not have survived.

"It's as if our Sun expanded its envelope so much that it swallowed up the inner planets as far as the Earth and Mars. The star HIP 13044 has passed this evolutionary phase and yet one planet is still there," explains Setiawan.

No planet has ever been discovered beyond the red giant stage before now, apart from a couple around pulsars. "We never expected to find a planet around a post-red giant," said Dr Setiawan. "But if you don't look, you don't find!"

Any planets that were closer in than HIP 13044b were almost certainly devoured by the star. It is rotating rather quickly for a star at this particular evolutionary stage, and Dr Setiawan believes this faster spin is due to the fact that it swallowed up its inner planets.

Final stages

The star has now moved on to what is known as the 'horizontal branch' of its evolutionary cycle. It has contracted again and is mainly burning helium in its core rather than hydrogen. It has settled down into a quiet phase that is expected to last a few million years.

Dr Setiawan accepts that stars generally lose a lot of their metals as they grow older, so that it is theoretically possible for a star like the Sun to become a red giant and to keep a distant planet of its own. But studies of other stars in the Helmi stream indicate that they are not like the Sun. The alien world's home star was therefore likely to have been metal-poor in the first place, because it formed when there were few heavy elements in the Universe.

"The majority of theories say that to build a planet you need a metal-rich star. We need to find how metal-poor a star can be and still be able to build planets. But the planet we found suggests that they can form around not just metal-poor stars but very metal-poor stars."

Explaining exactly how this planet formed is more difficult. "There are several theories of planet formation, of which the core accretion theory is the most widely accepted," says Dr Setiawan. "According to that theory, our new planet should not exist. However, there's another theory involving gravitational instability [see 'Planet formation', opposite]. That says it can form with no problem. Perhaps the answer is somewhere between the two."

Some astronomers wonder whether the planet might have been captured in an encounter with another star. But Dr Setiawan believes the chances of that are very low. For starters, the star was not from a cluster. It wasn't even part of a binary system, so it has had no close neighbours from which to steal a planet.

Fate is not destined to be kind to HIP 13044b. The present lull in its host star's behaviour is likely to end after a few million years, when it will expand once again. And then this strange alien world from another galaxy will be lost forever.

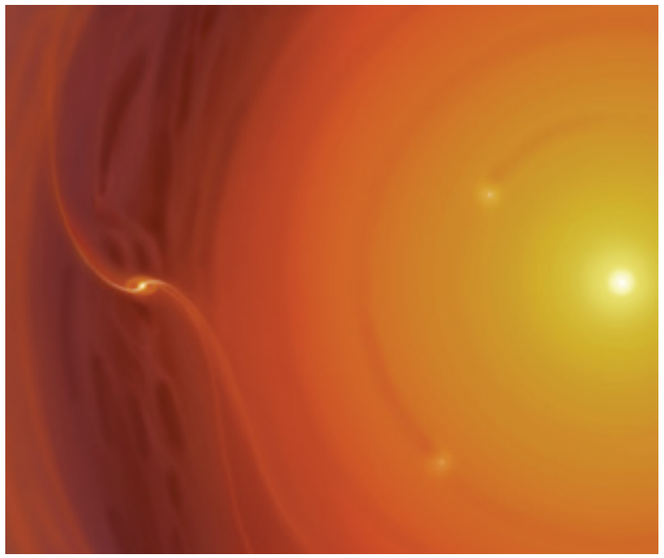
The expert

Sky at Night Magazine speaks to Johny Setiawan of the Max Planck Institute for Astronomy in Germany

How are you following up on the discovery?
The search for planets around evolved stars is very challenging but we are now examining stars from other stellar streams within the Milky Way. We want to know what proportion of these stars have planets compared to metal-rich stars. We want to find how metal-poor a star can be and still have planets.

What impact has the discovery of HIP 13044b made?
Such a planet has never been found before and it could have a big effect on current theories of how planetary systems form. It could also help us to understand what may be in store for our own Solar System after the Sun swells up to become a red giant in about five billion years' time.

Have you had any success with your search?
We have found another couple of interesting candidates using the same 2.2m telescope at La Silla. They appear to be metal-poor but we are still doing the research so I can't say much about them yet. It's not clear whether these stellar streams are from outside our own Galaxy or not.



▼ An impression of the process of core accretion; but could HIP 13044b have formed orbiting a metal-poor star?