BOOKS & ARTS

Looking for planets like ours

The hunt for habitable worlds near other stars brings home the realization that our own Solar System might not be as special as we think, says **Michael Brown**.

The Crowded Universe: The Search for Living Planets
by Alan Boss
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R. MITCHELL-RYALL, T. FARRAR/NASA; ESO

Ground-based telescopes have revealed exoplanets such as the three 'super Earths' in this artist's impression. The Kepler space telescope (left) could yield even more.

Some 250 years ago, the philosopher Immanuel Kant laid out an account of the Universe that sounds remarkably modern. In his *Universal Natural History and Theory of the Heavens*, he declared that moons go around planets, planets go around stars and stars go around the Milky Way. The Solar System had an understandable origin, and inevitable consequences:

"The planetary structure in which the Sun at the centre makes the spheres found in its system orbit in eternal circles by means of its powerful force of attraction is entirely developed, as we have seen, from the originally distributed basic stuff of all planetary material. All the fixed stars which the eye discovers in the high recesses of the heavens and which appear to display a kind of extravagance are suns and central points of similar systems." In other words, gravity takes stuff and turns it into stars, which are surrounded by swarms of planets, and it has done so everywhere you see a star in the sky.

Until recently, this fact could be verified for only one star: the Sun. Then, in 1995, astronomers Michel Mayor and Didier Queloz announced the discovery of the first planet orbiting a star other than the Sun (*Nature* **378**, 355–359; 1995). Today, almost 300 stars are known to have planets around them. It is not quite Kant's "all the fixed stars which the eye discovers", but it's getting close. It has been accepted since the seventeenth century that our Sun is not special, but is one of many stars in the Universe. Now, at the beginning of the twenty-first century, it is clear that our planets are not special either.

Except that some exoplanets are special. It is tempting to describe the many planetary systems that have been discovered so far as weird. Rather than the 'inevitable' orderly arrangement of our own Solar System — with small planets close, large planets far, and everything going around the Sun in near-circular orbits in a common disk — we have instead found that almost anything goes. Planets the size of Jupiter orbit their stars at distances closer than Mercury, other planets have orbits as elliptical as some comets in the Solar System, and others lie farther from their central star than anything in our Solar System. Weird indeed. The only type of planetary system that we have not found, it seems, is one like our own.

But the special position that our home system holds is now in jeopardy. *The Crowded Universe* tells the story of the development of NASA's Kepler space telescope, which was launched from Earth in March this year to orbit the Sun. Kepler's three-and-a-half-year mission is simple: to find the Earths. Kepler and a similar French-led mission, COROT, are the first ones with a chance to tell us whether planets like ours are as common as Kant hoped or as rare as some astronomers think.

Alan Boss, a planetary scientist at the Carnegie Institution in Washington DC, weaves the story of Kepler with the larger tale of the booming field of exoplanets. As someone whose career in astronomy has spanned the period Boss discusses, I am glad someone was taking notes. It is fun to revisit the days when each new planetary discovery was an exciting event. Multiple teams struggled to outdo the others with firsts. First planet at the distance of the Earth! First transiting planet! First multiple planet system! It is easy to forget that most of the exoplanet field is less than a decade old.

Boss adds the insider story of the definition of planets in our own Solar System, including an account of the inner workings of the International Astronomical Union committee that decided how to classify Pluto, Eris and the other small bodies that we now call dwarf planets. The demotion of Pluto from planet class was unassailably reasonable, but the events leading up to it were some of the more publicly comical occurrences in recent astronomical history. It is a reminder that — for all their command of the physics of the Universe — astronomers, being human, have the capacity for near-infinite folly.

But Pluto is just a distraction for Boss, and rightly so. The meat of *The Crowded Universe* is the race to find another Earth. It would have been easy for his writing to get caught up in the day-to-day minutiae of meetings and detailed descriptions of research progress. But Boss never forgets that we are privileged to live in a time when a revolution of near-Copernican magnitude is unfolding.

Even if the Kepler and COROT missions

do find an abundance of planets, the Kantian revolution will not be complete. The new planets might be exactly the same size as Earth and orbit their stars at the same distance, and although an astronomer might be willing to call such a thing Earth-like, most people will look for more. Does it have liquid water? Does it have a recognizable atmosphere? And, inevitably, could it — does it — support life?

Finding the answers to these questions will take decades. Kepler and COROT are merely steps along the way. In the meantime, we can take solace from Kant: "I am of the opinion that it is not particularly necessary to assert that all planets must be inhabited. However, at the same time it would be absurd to deny this claim with respect to all or even to most of them."

It took nearly 250 years to prove him mostly right the first time. With a little luck and perseverance — and, as Boss shows, a lot of work by astronomers around the world — the final step may just come a little faster. ■

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See www.nature.com/astro09 for more on the International Year of Astronomy.

Charting the heavens from China

The Dunhuang Star Chart
The British Library, London
Until 18 August 2009.

Along the ancient trade route of the Silk Road connecting China and the West, the Mogao Caves honeycomb the Mingsha Hill some 25 kilometres southeast of Dunhuang, a desert town in Gansu province. Excavated between the fourth and fourteenth centuries, the caves were Buddhist shrines and temples where travellers prayed for the success of their journeys.

In 1900, the Taoist priest Wang Yuanlu propelled the Mogao Caves to the status of an archaeological crown jewel when he stumbled upon a hidden library in Cave 17. It contained more than 40,000 manuscripts on a myriad of subjects, from religion, history, art and literature to mathematics, medicine and economics. The documents had been sealed in the cave by Buddhist monks in the eleventh century.

Among the manuscripts was an exquisite star chart. It shows the entire sky as visible from China, skilfully drawn by hand in red and black inks onto a fine, four-metre-long paper scroll. In 1907, archaeologist Marc Aurel Stein took the chart and more than 7,000 other cave manuscripts to the British Museum in London.

Dated to between 649 and 684 AD, the chart is the oldest extant graphical star atlas in the world, explains Susan Whitfield, director of the British Library's International Dunhuang Project, which aims to make information and images about the artefacts available on the Internet. The atlas is on display at the British Library in London this summer to celebrate the International Year of Astronomy.

The atlas is divided into two sections. One shows 26 drawings of differently shaped clouds accompanied by text on cloud divination. The other section portrays 12 star maps, each depicting a 30° division of the sky in the east–west direction, plus a map of the circumpolar sky. The star positions are drawn as observed from a latitude of 34° N, possibly from the Imperial Observatory in Chang'an (present-day Xi'an) or another site in Luoyang.

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The three stars that make up the familiar 'belt' of Orion are recognizable in this panel from the seventh-century star chart discovered near Dunhuang, China.

The atlas shows 1,339 stars arranged in 257 groups, or asterisms, two of which resemble the constellations of the Big Dipper and Orion. It includes faint stars that are difficult to see with the naked eye, and several in the Southern Hemisphere. The styles of the dots differentiate the three schools of astronomical tradition established during the Warring States period (476–221 BC), each of which adopted alternative names and descriptions for the star groups.

The positions of the brightest stars are surprisingly accurate to within a few degrees, says astronomer Jean-Marc Bonnet-Bidaud of the CEA, the French Atomic Energy Commission, who has studied the atlas together with Whitfield and Françoise Praderie of the Paris Observatory (J.-M. Bonnet-Bidaud, F. Praderie and S. Whitfield *J. Astron. Hist. Herit.* **12**, 39–59; 2009). Stars near the celestial horizon are drawn using a cylindrical projection, in which meridians are mapped to equally spaced vertical lines, and circles of latitude are mapped to horizontal lines. The circumpolar region uses an azimuthal projection, preserving the directions of the stars from a central point. These methods are still used in geographical mapping today.

Ancient Chinese astronomers divided the celestial circle into 12 sections to follow the orbit of Jupiter, known as the Year Star in China, which loops the Sun about every 12 years. The Jupiter cycle is also the basis for the 12 months of the year that make up the Chinese calendar. On the Dunhuang chart, the text accompanying each star map names that region of sky, the astrological predictions associated with it and the states of the Chinese empire thought to be influenced by that division.

The chart may have been reproduced from an earlier atlas by tracing it on to fine paper. It has no coordinate grid, and shares wording with another traditional astronomical text, *Yue Ling*, or *Monthly Ordinances*, which has been dated to around 300 BC. Yet it remains the earliest-surviving detailed map of the entire northern sky, pre-dating others by several centuries. Older star maps described only part of the sky. *The Book of Fixed Stars*, an Arabic work written by the Persian astronomer Abd al-Rahman al-Sufi (903–986 AD), displays individual constellations but gives no information on their relative positions. The