3. Shiloh, Y. *Curr. Opin. Genet. Dev.* **11,** 71–77 (2001).
4. Kastan, M. B. & Lim, D.-S. *Nature Rev. Mol. Cell Biol.* **1,** 179–186 (2000).
5. Abraham, R. T. *Genes Dev.* **15,** 2177–2196 (2001).
6. Zhou, B.-B. S. & Elledge, S. J. *Nature* **408,** 433–439 (2000).
7. Wahl, G. M. & Carr, A. M. *Nature Cell Biol.* **3,** 277–286 (2001).
8. Lukas, C. *et al. Cancer Res.* **61,** 4990–4993 (2001).
9. Wolffe, A. P. & Guschin, D. *J. Struct. Biol.* **129,** 102–122 (2000).
10. Koyama, H., Itoh, M., Miyahara, K. & Tsuchiya, E. *FEBS Lett.* **531,** 215–221 (2002).
11. Rouse, J. & Jackson, S. P. *Science* **297,** 547–551 (2002).
12. Shimada, K., Pasero, P. & Gasser, S. M. *Genes Dev.* **16,** 3236–3252 (2002).

Astronomy

Distant planet is the hottest yet

Timothy M. Brown

The first planet beyond our Solar System to be detected by means of the transit method has now been found to orbit its star almost twenty times closer than Mercury orbits the Sun.

In recent years, more than 100 planet-like bodies have been detected orbiting distant stars. Until now, all of these 'extrasolar' planets have been located through their gravitational effect on their parent star. An alternative method of planet-finding is to look for 'transits' — the passage of a planet in front of its star that causes a dip in the light intensity seen at the Earth. Building on brightness observations by Udalski *et al.*[1,2], Maciej Konacki and colleagues[3] (page 507 of this issue) present delicate measurements that may confirm the first detection of an extrasolar planet by the transit method. This discovery is important for two reasons. First, the validation of the transit method has implications for many other planet-detection projects. Second, the inferred planet is closer to its star than any other planet yet seen, and further study may help to clarify some mysteries of the planet-formation process.

Since the first discovery[4] of a planetary companion to a Sun-like star, in 1995, extrasolar planets have confounded theoretical expectations. A substantial fraction of them are similar in mass to Jupiter, but move in orbits very close to their stars. The sizes of planetary orbits are usually given in terms of the astronomical unit (AU), which is defined as the average distance between the Earth and the Sun. The closest planet to our Sun is Mercury, which orbits at a distance of about 0.4 AU. In contrast, about a dozen extrasolar planets have been found with orbital radii between 0.05 and 0.1 AU. How such massive planets arrived in such tiny orbits remains a difficult question to answer, although there are some plausible theories[5,6].

In general, it should be much easier to detect a dip in a star's brightness resulting from the transit of a planet than to detect the gravitational tug of the planet on the star. Furthermore, using modern imaging detectors, thousands of stars can be monitored simultaneously. Yet, of the 100 or so extrasolar planets found, this is the first to be detected through its transit (one transiting extrasolar planet has been seen, but it was discovered through its gravitational pull on its star[7,8]). This is because only a small fraction of extrasolar planets actually produce transits. Transits occur only if the Earth happens to lie nearly in the plane of the planet's orbit; otherwise, the planet never passes across the disk of its star, as seen from Earth (Fig. 1). In fact, the chance of producing transits increases with decreasing orbital radius, so close-in planets are much more likely to be seen in transit than are those that orbit far from their stars. Hence, the transit method is particularly suited to studying planets in small orbits. Also, the depth of the brightness dip provides a direct measurement of the relative sizes of the planet and the parent star.

The past three years have seen vigorous attempts to locate transiting planets by searching for their characteristic brightness dips (Fig. 1). The first lesson learnt from these efforts has been that there are many double- and multiple-star systems that can masquerade as transiting planets, and the trick is to separate the real planets from these interlopers. The success of Konacki *et al.*[3] is largely attributable to a systematic method for doing this. They began with brightness records for 59 stars that seemed to display a transit-like dip, put forward from a larger sample analysed by Udalski *et al.*[1,2]. Through a series of tests and observations, Konacki *et al.* were able to reject about 90% of these candidates, judging them likely to be stellar, not planetary, systems. The final step was to examine the spectra of the remaining half-dozen stars. The light from the stars suffers a 'Doppler shift', with its wavelength being lengthened (or shortened) if the star is moving away from (or towards) the observer. The gravitational pull of an orbiting low-mass planet causes a very slight variation in the star's radial velocity, which can be picked up in the Doppler-shifted spectrum of light from the star and can also be used to deduce the mass of the orbiting planet.

The measurements made by Konacki *et al.* were particularly difficult, because the stars in question are typically several hundred times fainter than those normally targeted using this 'radial-velocity' technique. Nevertheless, they found that the radial-velocity measurements for one of the surviving candidates, OGLE-TR-56, match the expectations for a planet that has a mass slightly lower than Jupiter's, but an orbital radius of only 0.023 AU, or just under 3.5 million kilometres. If this is indeed a planet, it has the smallest orbital radius yet seen (by a factor of about two) and is consequently the hottest planet known — its dayside temperature is probably about 1,900 K. Konacki *et al.* suggest that the new planet may have a different history from other known planets, in that it may have lost a significant amount of mass to its parent star before settling into its current orbit.

Exciting as these data are, the sampling is quite poor over the full duration of the planet's orbit. Although non-planetary explanations of the observed variations seem to be ruled out, the planet interpretation will be stronger when the radial-velocity curve has been filled out with additional observations (see Fig. 1a on page 507). Planned space

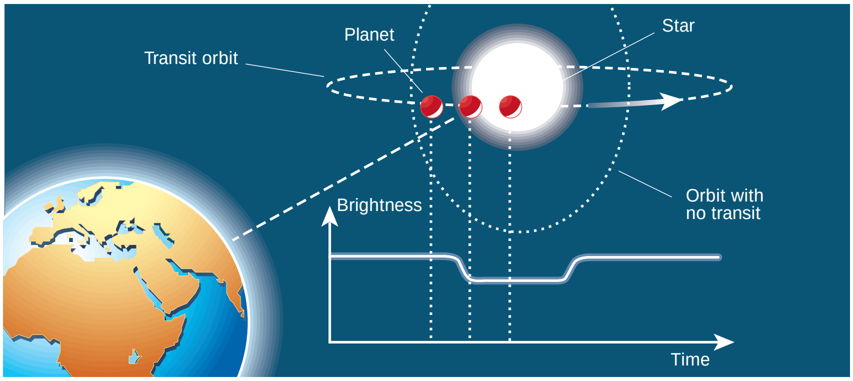

Figure 1 **Planetary transit. The passage of a planet in front of a distant star produces a characteristic dip in the star's brightness, as perceived at the Earth. The apparent discovery of an extrasolar planet using this transit technique may now be confirmed by Konacki and colleagues' observations[3]. Although more than 100 extrasolar planets have been found, this is the first such planet to be detected through its transit: for the brightness dip to be seen, the line of sight from the Earth to the star must lie close to the plane of the planet's orbit.**

experiments, such as the European Space Agency's Eddington and NASA's Kepler[9] missions, will also search for extrasolar planets through their transit signatures. Avoiding the data deterioration caused by the Earth's atmosphere, these aim to locate planets as small as, or smaller than, the Earth. The success of Konacki *et al.*[3] should inspire even greater enthusiasm for the promising projects soon to come. ■

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1. Udalski, A. *et al. Acta Astron.* **52,** 1–37 (2002).
2. Udalski, A. *et al. Acta Astron.* **52,** 115–128 (2002).
3. Konacki, M., Torres, G., Jha, S. & Sasselov, D. D. *Nature* **421,** 507–509 (2003).
4. Mayor, M. & Queloz, D. *Nature* **378,** 355–359 (1995).
5. Goldreich, P. & Tremaine, S. *Astrophys. J.* **241,** 425–441 (1980).
6. Murray, N., Hansen, B., Holman, M. & Tremaine, S. *Science* **279,** 69–72 (1998).
7. Henry, G., Marcy, G., Butler, R. & Vogt, S. *Astrophys. J.* **529,** L41–L44 (2000).
8. Charbonneau, D., Brown, T., Latham, D. & Mayor, M. *Astrophys. J.* **529,** L45–L48 (2000).
9. Lissauer, J. *Nature* **419,** 355–358 (2002).

Biodiversity

The threat of small households

Nico Keilman

Many studies have suggested that the increasing global human population is having a negative effect on biodiversity. According to new work, another threat comes from the rising number of households.

Households in many countries have become smaller in recent decades. Between 1970 and 2000, the average number of occupants in households in less developed countries fell from 5.1 to 4.4. And in more developed nations, the decrease was from 3.2 to 2.5 people per household over the same period (the decline began earlier; Fig. 1). From their analysis of household dynamics in biodiversity 'hotspot' areas, Liu and colleagues[1] now argue (page 530 of this issue) that the decline in household sizes has unintended negative effects. The global human population has risen, not fallen, so smaller households means more households — and a higher demand for natural resources. This is in addition to the increased demand resulting purely from population growth.

Even before the writings of Thomas Malthus in the late eighteenth century, the balance between population and natural resources was a recurrent theme. Since ancient times, statesmen and philosophers have expressed opinions about such issues as the optimum number of people and the disadvantages of excessive population growth[2]. Although some theorists see population expansion in a positive light[3,4], there is increasing concern about the negative consequences for resources[5]. Other things being equal, a larger population implies a greater demand for food, water, arable land, energy, building materials, transport and so on — a link that was first quantified some 30 years ago[6]. A population's age structure also influences economic growth and hence resource use: a rapid growth of the young age segments decelerates economic growth[7].

More recently, scholars have acknowledged that another demographic variable — the number of households — also has an important role in resource consumption[8–11]. Even when the size of a population remains constant, more households imply a larger demand for resources. Household members share space, home furnishings, transportation and energy, leading to significant economies of scale. For instance, two-person households in the United States in 1993–94 used 17% less energy per person than one-person households[11].

To appreciate the different effects of population size and number of households on resource consumption on a larger regional scale, consider the following example[8]. In more developed regions, energy consumption increased by 2.1% per year over the period 1970–90. Population growth can explain 0.7 percentage points of this growth in energy usage, while changes in per capita energy use explain the remaining 1.4 points. However, an alternative analysis decomposes the growth in energy consumption into a factor that describes the growth in number of households and a factor describing per household energy use. This analysis shows that the household growth factor explains 1.6 percentage points of the energy-consumption increase — more than twice as much as the population growth factor.

Liu and colleagues[1] now draw our attention to household dynamics in biodiversity hotspot areas — regions that are rich in endemic species and threatened by human activities. They find that, during the years 1985–2000, the number of households in 76 hotspot countries increased by 3.1% per year, substantially faster than did the population (1.8% per year). So, average household size fell by about 1.3% per year. These changes relate to the group of 76 countries as a whole. For individual hotspot countries, more than 80% showed a pattern of greater growth in household numbers than in population. In 65 non-hotspot countries, however, population increased at roughly the same tempo as household numbers during 1985–2000.

Many of the world's most populated countries are hotspot countries (such as China, India, Indonesia, Brazil and Bangladesh). And most of the hotspot countries studied by Liu *et al.* (65 out of 76) belong to the group of less developed nations. We know that falling birth rates were an important driving force behind reductions in average household size in less developed countries in the 1990s (ref. 12). Despite these falling birth rates, however, the population in such countries did increase (because of decreased death rates, for instance). All of this might explain why increases in the number of households were relatively pronounced in hotspot countries[1].

Liu *et al.* also refer to projections of population size and the number of households over the next 15 years. These projections suggest that the divergence in population growth and household numbers will become more pronounced. So, the authors argue, it is crucial to consider average household size when assessing threats to biodiversity. Quantifying the impact of falling household sizes, and increasing household numbers, on biodiversity changes should have high research priority.

Small households have adverse effects on resource consumption both because they are less energy-efficient in themselves and

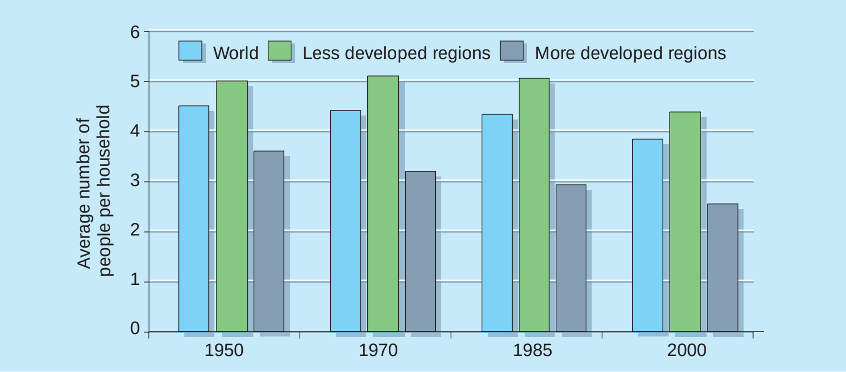

Figure 1 **Decline and fall in household sizes. Data for 1950 and 1970 are taken from ref. 8; data for 1985 and 2000 are from ref. 17.**