ASTRONOMY

HOT JUPITERS

Why do some giant planets hug their stars?

Last year, when Michel Mayor and Didier Queloz of the Geneva Observatory reported the first solid evidence of a planet circling a sunlike star outside the solar system, many astrophysicists were taken aback. These observations showed what could be a Jupiter-size planet orbiting quite close to the star 51 Pegasi; it was about seven million kilometers away—only a small fraction of the distance between the sun and Mercury. Yet existing theories for the development of planetary systems indicated that such giant planets should form at much greater distances from a star. What was a big planet doing so close in?

Some initially believed that the old theories were fine and that 51 Pegasi was simply the exception that proves the rule. After all, the technique that Mayor and Queloz had used was most sensitive to large planets in tight orbits. But further discoveries over the past year have uncovered nine other "extrasolar" planets, and three of these bodies, in addition to the one around 51 Pegasi, are rapidly circling at a celestial hair's breadth from their stars. Astronomers now surmise that such "hot Jupiters" might, in fact, be commonplace.

"I don't think any of us were prepared to see these three-day- or four-day-period Jupiters," says George D. Gatewood, director of the University of Pittsburgh's Allegheny Observatory, referring to the short times needed for such planets to complete their diminutive orbits. Indeed, just seven months before the discovery

FIELD NOTES

Bring Me a Shrubbery

I am on an experimental farm near Syracuse in upstate New York, standing next to dense thickets of a tall woody shrub that is bereft of any edible fruit and would certainly lose in an arboreal beauty contest. The shrub, a hybrid willow, sends out a vigorous green spray of whiplike stems that climb as high as 11 feet in a single year. Although the double rows of identical plants are five feet apart, the stands are impenetrable: the profusion of wood and leaves is literally arresting. The willow would seem an unlikely crop, but if Edwin H. White of the State University of New York's College of Environmental Science and Forestry has his way, it could become common in much of the northern U.S. By 2010, farmers may be growing 50,000 acres of the stuff in New York alone.

RANDI ANGLIN

Shrubbery would not normally warrant an intensive research effort, but to White and local power companies—and now the Department of Energy—the prodigious growth rate of these hybrid willows makes them a potential source of clean-burning fuel. They produce five to 10 times more wood every year than any natural forest. A 50,000-acre crop would be worth $20 million.

White, who is dean of research, has spent the past 10 years investigating how to cultivate the plant. He is convinced that the U.S. and other countries should make more use of wood for energy. Burning farmed wood in power stations reduces reliance on foreign oil and curtails emissions of carbon dioxide (although trees produce the gas when they are burned, they take it out of the atmosphere while growing).

Hybrid willow shrubs—which look nothing like the familiar tree—appear to be the most promising biomass fuel for the U.S., White says. Once established they are extremely hardy, tolerating marginal land with only irrigation and some added nitrogen. The basic cultivation scheme was developed in Sweden; 50,000 acres are now grown in Europe. The shoots, which readily grow from sticks, are cut back at one year, and the wood is harvested every three years thereafter for about 20 years. Researchers are studying a patchwork of varieties.

Burning wood is, of course, hardly a new idea, but its high cost means that very little is used in the U.S. New York State Electric and Gas Corporation (NYSEG) is one of a small number of power companies nationwide that have investigated using waste wood, chipped into two-inch lumps, for burning along with coal. Michael Tesla of NYSEG says he aims eventually to burn willow in 1/4-inch flakes.

Although willow will cost hardly less than coal for the same amount of energy when equipment costs are figured in, power companies see it as a valuable way of cutting about 10 percent from their sulfur emissions, which are limited by tradable permits, as well as emissions of nitrogen oxides, which may be limited in the future. The companies also recognize its potential as a hedge against the possibility that carbon dioxide emissions from fossil fuels might someday be taxed.

The federal government is offering willow a jump start. The DOE and the U.S. Department of Agriculture earlier this year signed an agreement with a consortium of New York power companies, agencies and academic institutions to establish 2,600 acres of willow as a demonstration project. The energy department will provide 36 percent of the estimated $14-million cost. Although in New York the project will initially focus on burning wood directly, in other states it will eventually include burning gas produced by heating the wood. White notes that there are 200 million acres of abandoned farmland in the U.S. I don't need to ask what he would like to see growing on them 20 years from now.

—Tim Beardsley

IN BRIEF

Making Voting a Science

Both leading presidential candidates have paid scant attention to science during the campaign, despite agreement that research stimulates growth.

AP/WIDE WORLD PHOTOS

ASSOCIATED PRESS

Bob Dole's pledge to lower taxes by 15 percent would demand large cuts in civilian research and development; Representative George Brown, a Democrat from California, projects reductions as large as 40 percent by 2002, with cuts falling especially hard on the Departments of Energy and Commerce. Nor does President Bill Clinton's balanced budget plan look auspicious: the American Association for the Advancement of Science says it implies a 19 percent drop in nondefense R&D over the same period. Congressional staff say total R&D as a proportion of gross domestic product is likely to fall from 2.4 to about 2.1 percent.

Sickle Cell Successes

This past summer it became clear that bone marrow transplants could probably cure some children suffering from sickle cell anemia, a genetic condition in which abnormally shaped red blood cells clog capillaries and cause life-threatening tissue damage. Recently hope has come to many more. In September researchers at Thomas Jefferson University reported on a new synthetic molecule—called a chimeraplast—that in laboratory tests can actually repair the responsible genetic malfunction. Clinical tests should begin soon.

Affirmative Reaction

What's good for the goose *is* good for the gander. In 1990 researchers at the Johns Hopkins School of Medicine initiated a series of changes—among them correcting salary inequities—to minimize sexual bias at the school. This year's follow-up found that while the changes made academic medicine an easier career choice for women, they also gave many more gifted men a chance at success. Those planning to leave the field fell by 63 percent among women and by 42 percent among men.

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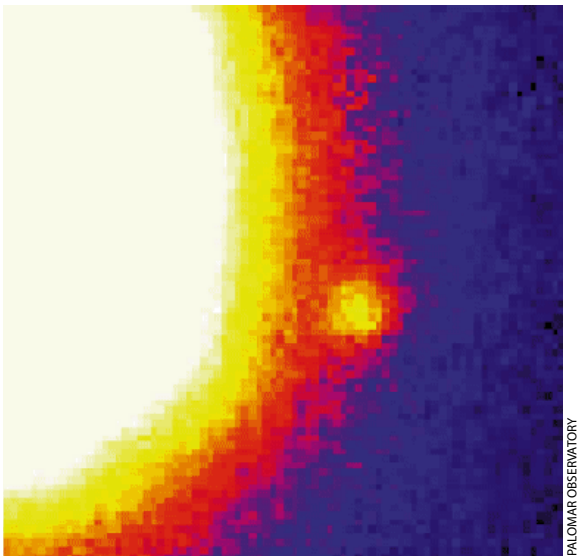
of the planet around 51 Pegasi, Alan P. Boss, a theoretical astrophysicist at the Carnegie Institution of Washington, showed that Jupiter-like planets most likely form at approximately five times the Earth-sun separation (an often used yardstick called the astronomical unit, or AU, a distance of about 150 million kilometers), even when the parent star is quite small.

Recently Douglas N. C. Lin of the University of California at Santa Cruz and two colleagues offered one way around the conundrum. They argued in the journal *Nature* that a Jupiter-like planet would form at about 5 AU and then gradually spiral inward, along with the disk of dust and debris (called the planetary nebula) out of which the planet originally formed. This inward migration is inferred from the basic physics governing the motions of orbiting material.

Yet the mechanism for halting that orbital decay remains somewhat speculative. Lin and his coworkers offer two possibilities. In one scenario, the decay continues until the large planet is brought sufficiently close to raise a tidal bulge on the central star. If this star rotates faster than the planet orbits, the tidal bulge would tend to spin ahead of the planet. The massive bulge would then exert a gravitational pull that helps to speed the planet along in its orbit, counteracting the ongoing tendency to spiral inward. The second possibility involves the magnetic field of the star, which could sweep the inner region of the nebula clear of dust and gas. Once the planet had spiraled to a position within this open zone, its propensity to lose momentum to nearby parts of the nebula would wane. Therefore, the tendency for the planet to slow and its orbit to decay further would be greatly reduced. According to Lin and his colleagues, "the migration effectively stops near 0.05 AU." Although heated intensely by the star in this final position, a giant planet would have sufficiently strong gravity to keep many of the volatile substances that would otherwise be difficult for a hot planet to hold.

Some astronomers do not accept either of Lin's explanations. "The Lin hypothesis is nice, but it's a hypothesis," remarks R. Paul Butler of San Francisco State University, a member of one of the several groups turning up new planets around distant stars. He points out that rather than being gaseous bodies like Jupiter (which could have formed only in the outer, cooler parts of the primordial nebula, where ices and gases abound), they could be "giant nickel-iron bowling balls." And so like Mercury, they may have originated from the refractory particles that existed in the hot, inner parts of a planetary nebula. Similarly, Jack J. Lissauer, a planetary astrophysicist at the National Aeronautics and Space Administration Ames Research Center, believes that although the theory makes good sense, the case for inward planetary migration is still not settled.



PALOMAR OBSERVATORY

ORBITING COMPANION *of the star Gliese 229 resembles a "hot Jupiter."*

The origin of these massive bodies critically affects the evolution of these planetary systems. Boss notes in a recent issue of *Physics Today* that if the newly discovered planet around 51 Pegasi indeed migrated from a distant formation zone to its current position, it "would have ejected or otherwise destroyed any Earth-like planets it might have encountered." But Lin points out that other Earth-like planets could have formed in its wake. So perhaps the prospects for finding far-flung counterparts to our home planet is not compromised. At this point, with theoreticians struggling to catch up with the rush of new discoveries, the variety of extrasolar planetary systems remains anyone's guess. As Butler says, "It's all brand-new and all very wild." —*David Schneider*