THE PLANET HUNTERS

BY MARCIA BARTUSIAK

Are we unique? Are we alone? Is ours the only sun with planets? The eager pioneers of a new branch of astronomy may already have found answers to these cosmic questions.

Astronomers do not like to think that our solar system is a unique specimen in the cosmos. In a galaxy of 100 billion stars, in a universe of 100 billion galaxies, it seems improbable that our sun is the sole owner of planetary real estate: four gas giants and a motley assortment of rocky and icy spheres. Could the universe really be so stingy? Most likely, it is not.

Yet we have never seen a planet around another star, or even found solid evidence for one. We are getting closer, though. In recent months, astronomers discovered that the fifth brightest star, Vega, is surrounded by a disk of cold matter that may contain bodies as large as Jupiter. Other astronomers, examining a young star named T Tauri, have come to suspect they are witnessing—for the first time—the birth of a planet around this stellar adolescent. Still others, who have been photographing Barnard's star for the past 45 years, believe it is wobbling and say that its agitators are two unseen planets.

Thus, evidence is mounting in favor of the existence of alien planets. And, with advanced instruments now, or soon to be, in operation on the ground and in space, planet hunting promises to be an important branch of astronomy for the 1980s.

STAR IN THE LIMELIGHT

It was IRAS, the orbiting Infrared Astronomy Satellite, that thrust Vega into the limelight. George H.H. Aumann, of NASA's Jet Propulsion Laboratory, and Fred Gillet, of Kitt Peak Observatory, had been using Vega to test the sensitivity of IRAS's instruments. What they found was that the hot star, 50 times more luminous than our sun, had more longer, or "cooler," wavelengths than they had expected.

According to Gillet, the idea that the abnormality had anything to do with material around Vega was "the farthest thing from our minds." But after gradually ruling out other explanations, it began to dawn on the astronomers that they might be looking at another solar system. "We were getting more excited as time went on and we were ruling out the various other options; it was a lot of fun," says Gillet.

Exactly how much actual planetary real estate is orbiting Vega remains an open question. The astronomers found that the cloud of material has a radius of roughly seven and a half billion miles, making it about twice the size of our solar system. According to Aumann, the IRAS data do not directly reveal the exact shape the material has assumed, but the laws of orbital mechanics provide some clues. "I think there is very little doubt that the material is in the form of a disk of sorts," he says.

The material is not typical interstellar dust, because Vega's intense solar wind would have blown such small particles away long ago. The debris also has to be at least the size of buckshot, because particles smaller than a few millimeters would have slowly spiraled inward and been swallowed up by the star.

Such theoretical considerations place a lower limit on the particles' size, but provide few constraints on how large a body may lurk within the disk. "You can make the biggest objects in there as big as Jupiter and not run into significant problems," says Aumann.

Though Aumann and Gillet became planet hunters more by chance than design, Peter van de Kamp and his colleagues at the Sproul Observatory at Swarthmore College have been hunting for 45 years. They have been regularly photographing the motion of Barnard's star, a faint red dwarf six light-years away, as it "speeds" across the sky at three-thousandths of a degree per year. It is shifting its position in the heavens by the width of the moon every 180 years, faster than any other star.

According to van de Kamp, now with the University of Amsterdam, painstaking measurements of 1,200 photographic plates indicate that the motion of Barnard's star deviates ever so slightly from a smooth, straight path—not unlike the wobble of an unbalanced tire. This periodic wiggle indirectly suggests that two planets with approximately the mass of Jupiter and Saturn

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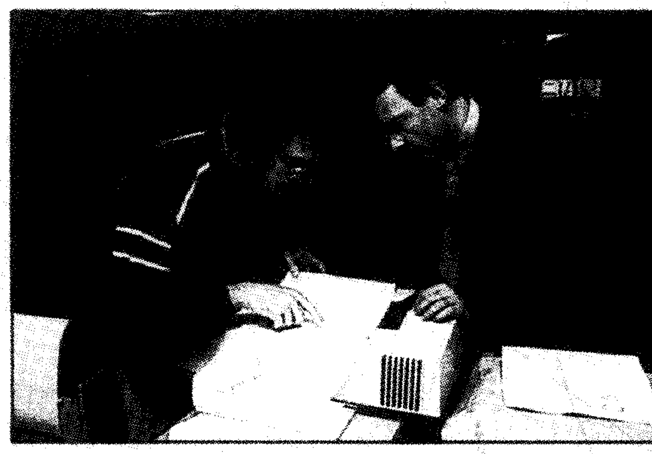
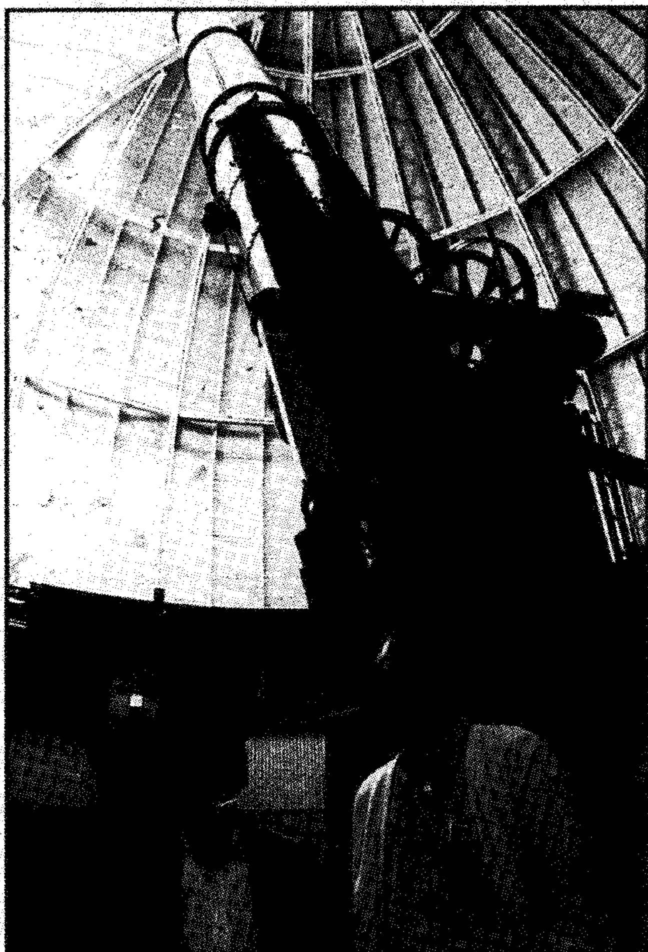
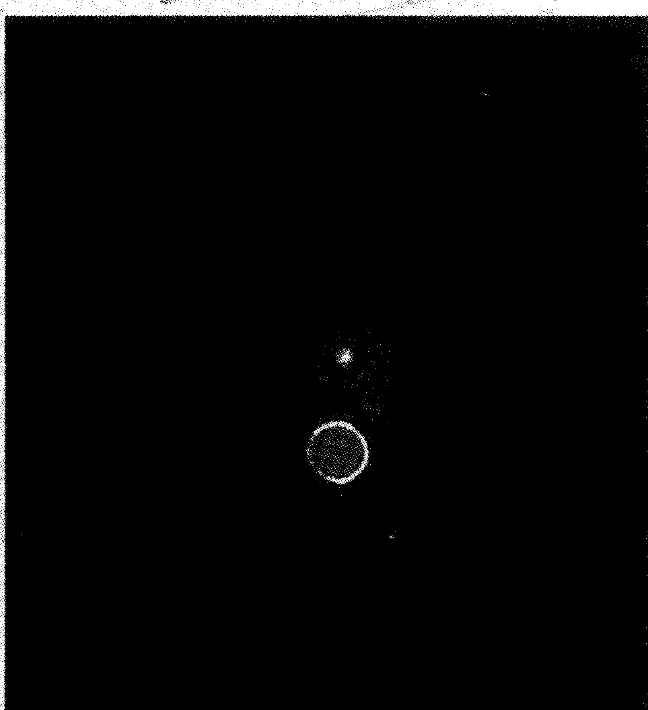


(Top) The serendipitous discovery of what might be another solar system around the star Vega was made by astronomers Fred Gillet, left, and George Aumann. (Right) An artist envisions Earthlike planets forming within Vega's whirling disk of matter.

Photograph by Pete Addis; illustration by David Egge





(Top) By measuring the paths of stars with exquisite precision, astronomers George Gatewood, left, and John Stein hope to find infinitesimal wobbles that could indicate the gravitational tug of invisible planets. (Bottom) Some astronomers think that this enhanced radio image of the star T Tauri, top, and an infrared companion shows a planet being born, 450 light-years from Earth.

are tagging along and producing the unbalanced tire.

Swarthmore's survey has even turned up four more possible planet owners, all of them red dwarfs invisible to the naked eye and located within 30 light-years of Earth. Sarah Lee Lippincott, director emeritus of the Sproul Observatory, estimates that the unseen companions circling these dwarfs range from 2 to 20 Jupiter masses, sort of almost-stars. "You need at least sixty Jupiter masses to start nuclear burning in a star," she notes.

But the Sproul findings are hotly debated. Other astronomers claim that the measurements are still too fuzzy, too fraught with systematic errors.

But all this uncertainty may soon disappear, perhaps within a decade. In recent years a small group of astronomers has been assembling a bevy of new instruments to search for extrasolar planetary systems. As with the Barnard's star measurements, the detection schemes will be indirect. Sensitive photoelectric arrays, spectrometers and interferometers will replace the traditional photographic plates, increasing the ability to detect those stellar wobbles a hundredfold. After about 10 years of patient mapping, they hope to know whether giant Jupiter-size planets are truly circling nearby stars; instruments sent into space may be able to detect Earth-size masses.

COSMIC PETRI DISHES

Such a quest, of course, has a strong emotional pull because it will help answer the ancient question: "Are we alone?" Perhaps we're just a solitary outpost in the boondocks of this galaxy. "I view planets as sort of cosmic petri dishes," remarks David Black, an astrophysicist with the NASA Ames Research Center in California. "If we find they're extremely rare, then it greatly affects our search for extraterrestrial intelligence. But if planets are plentiful, then you have a stronger feeling that intelligent life can exist within a reasonable distance of our solar system."

Black, who is in charge of allocating about $200,000 a year in NASA money to researchers in this burgeoning field, says he's "desperately pushing for this kind of information" to help him in his own speciality—star formation. Do planets evolve naturally out of the disklike material that condenses to form a star, or does the process require a rare, catastrophic nudge? Finding one isolated planet or low-mass object is not enough, according to Black. "We're never going to understand the origin of our own solar system until we can compare it with many other systems, stars with two or more dark companions," he says. "For example, are they all structured alike, gas giants at the edge with a few insignificant pebbles like Earth rotating around inside?"

George Gatewood, an astronomer with the University of Pittsburgh's Allegheny Observatory, is ardently trying to answer that question, an ironic turn of events, since, only a few years ago, he had a reputation for "wiping out entire solar systems," as he puts it. His own photographic survey of Barnard's star failed to confirm the Sproul findings. This led Gatewood and his colleague John Stein to design an electronic means of following a star's path through the heavens. Instead of placing a photographic plate at the focus of their 30-inch refracting telescope, they now mount an array of fiber-optic lines, each strand recording the starlight it gathers on a sensitive photoelectric detector.

In one night, this Multichannel Astrometric Photometer (MAP), as they call it, can pinpoint a star's position to within a millionth of a degree of arc (by comparison, the sun and moon each span about half a degree). Currently, a year's worth of photographic measurements must be averaged to get such accuracy. MAP will enable planet hunters to discern wiggly stellar paths with much more confidence, but *not* with more speed. As

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Marcia Bartusiak, who has a master's in physics, often writes about new developments in astronomy. Randall Black helped her research this story.

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Gatewood says, "The first results will probably be in by the time I retire." To make sure that a planet is indeed tugging at a nearby star, they have to follow at least one full wobble; a dozen years is a reasonable time frame for seeking out Jupiter-size companions, since our own Jupiter takes 12 years to circle the sun.

A STAR'S WOBBLE

Part of a star's wobble toward and then away from the Earth would regularly shift the wavelengths of light emitted by the star. When the star's planet tugged it in the direction of Earth, the light would be "Doppler shifted" to a higher frequency in much the same manner that the whine of a car's engine sounds higher when it moves in the direction of a listener. As the star is pulled away from us, the wavelengths of its light will stretch out, lowering the frequency. Astronomers soon recognized that such rhythmic wavelength changes could also signal the presence of a planet. Right now, groups in Arizona, California and Canada are designing the equipment needed to detect these subtle Doppler shifts.

Gordon Walker, an astronomer with the University of British Columbia, and Bruce Campbell, of the Dominion Astrophysical Observatory, have already mounted their instrument on the 3.6-meter Canada-France-Hawaii telescope located on Hawaii's lofty Mauna Kea. Over the past two years, they've periodically measured the radial velocities—the speed at which a star is receding or approaching—of 31 nearby stars to within 10 meters per second, a level that could potentially detect faraway Jupiters. "It's a bit of a long shot," Walker admits. "They'll need eight more years of measuring these radial oscillations before answers can be forthcoming."

Directly detecting the dark companions of nearby stars from the ground in one evening's work is not impossible. Astronomer Donald McCarthy, of the University of Arizona, found that out quite by accident. When aiming a device called an infrared speckle interferometer at Zeta Aquarii, a well-known double star 75 light-years away, to calibrate his instrument, he saw not two stars but three!

A PATTERN OF SPECKS

In McCarthy's case, the pattern of specks indicated that Zeta Aquarii's third member was a cool, low-mass star about one-quarter the size of our sun. His equipment was able to detect its faint traces of heat radiation because such tiny stars shine much more brightly in the infrared. He and his colleagues have since discovered 20 more of these low-mass objects.

Another infrared speckle interferometer has already spotted intriguing goings-on within the T Tauri system, located 450 light-years from Earth. More than a year ago, astronomers H. Melvin Dyck and Theodore Simon, of the University of Hawaii, and Ben Zuckerman, now with UCLA, mounted their detector on the 2.2-meter telescope on Mauna Kea, pointed it at T Tauri and soon noticed that the 2-million-year-old star has an active infrared companion about 7 to 9 billion miles away (more than twice the distance between Pluto and our sun).

A team of astronomers from the University of California, Santa Cruz, recently proposed that the companion is a planet in the throes of birth, forming out of a turbulent disk of gassy material. The intense infrared radiation we detect from it, the scenario goes on, is being emitted as the protoplanet condenses. Santa Cruz theoretician Douglas Lin estimates from his model that the object now contains the mass of 10 Jupiters within a diameter of 300,000 miles. Over the next 100,000 years, Lin expects this intriguing object to gather enough material to equal the mass of 20 Jupiters.

"I'D BE THRILLED"

But other astronomers are very cautious about Lin's hypothesis. "I'd be thrilled if it turns out to be a protoplanet," says Dyck, "but there are many other ways to interpret this infrared data." It could be, he suggests, a newborn star.

Several proposals for launching space telescopes capable of detecting planetary systems are on the drawing boards. Some proposed satellites will carry out the indirect but extremely precise astrometric measurements of van de Kamp and Gatewood. One instrument will be the Coherent Optical System of Modular Imaging Collectors (COSMIC). According to a NASA report, COSMIC will be accurate enough to "permit detection of an Earth-mass planet around a solar-type star out to a distance of 30 light-years."

SHARPER-SIGHTED SCOPE

The Shuttle Infrared Telescope Facility (SIRTF) promises to dramatically extend space-based infrared astronomy beyond the already magnificent accomplishments of IRAS. "It is going to be potentially a hundred to a thousand times more sensitive," says Michael Werner, study scientist for SIRTF at NASA's Ames Research Center. According to Werner, SIRTF will be able to see Vega-type phenomena at 10 to 30 times the range of IRAS and perhaps even sight individual Jupiter-like objects to a distance of approximately five light-years.

A Jupiter-like object may appear as a small dot that slowly moves around the star, not unlike Galileo's first view of Jupiter's moons almost four centuries ago. It could be the bait that finally lures man out of the solar system. "Man has never had a carrot dangle in front of him that he didn't go after sooner or later," muses Gatewood. "If man finds an Earth-size planet circling a nearby star, he's eventually going to probe it," just as mankind was enticed by the moon for untold generations before going there.

Of course, finding out that our sun possesses the only planetary system in the galaxy would be just as intriguing. ■

ARE PLANETS COMMON?

Is the matter orbiting Vega just a disk of dust, or does it mean that planets—even Earthlike planets—may be common in the universe? *Science Digest's* April Lasher asked astronomers for their reactions to the recent remarkable discovery.

• People who speculate about life in the cosmos always assume there are lots of Earthlike planets around, but they have no proof whatsoever. The Vegan observation reveals a stage leading to the formation of planets—a step toward direct proof.
–Robert Jastrow, Dartmouth College

• The Vega observations certainly raise one's confidence that planetary objects around stars are common.
–Joe Patterson, Columbia University

• I would be very surprised to find there weren't an awful lot of planets out there—and ones with all the proper attributes to support life.–*G. David Brin, California Space Institute*

• The Vega results certainly make us all believe a little more that planetary systems may occur frequently in nature. And to find other planetary systems is the only way we will ever understand our solar system.–*David Black, NASA Ames Research Center*

• People have believed there are other planets, but thought they only occurred around stars of the sun's mass and lower. That you can have material surrounding a star *more* massive than the sun was a surprise to me. *–Steve Willner, Center for Astrophysics*

• The discovery is encouraging because it shows that there *is* dust from which planets may form. It teaches us to look for more places where there is dust.
–Ron Bracewell, Stanford University

• That something as obvious as what has been discovered has escaped astronomers makes me wonder what else we have failed to see.
–George Aumann, JPL