geodynamo created by the outer core's churning, conductive liquid iron, which generates the magnetic field. Reflecting the truly frontier nature of the inner core, "we don't know what the magnetic field's magnitude is in that region," notes Stevenson. A comparison of the model's inner-core rotation rate with the observed rate would seem to confirm the model's prediction that the field at the inner core is 100 gauss—200 times stronger than at the surface.

Still, "there are a lot of uncertainties in the modeling and the seismology," says Glatzmaier. "So a big question remains—is Earth doing the same thing as our model?" As far as the inner core goes, says Creager, it's too soon to tell for sure. The core is rotating faster than the rest of the planet, "but I think it's premature to say [just] how fast." The new preliminary estimate could have been thrown off by variations in the strength of the anisotropy from place to place in the inner core, he says: "It's becoming clear that the inner core is a little more complicated than we gave it credit for."

–Richard A. Kerr

For more information, see the Lamont-Doherty World Wide Web page on inner core rotation: http://www.ldeo.columbia.edu/song/pr.html

PLANET HUNTING

'Hot Jupiters' Leave Theorists in the Cold

CAPRI, ITALY—It has been just 10 months since a pair of Swiss astronomers first identified a planet orbiting a sunlike star other than our own, but the tally of so-called "exoplanets" has now passed the total of nine familiar planets of our solar system. That mark came earlier this month at the Fifth International Conference on Bioastronomy on this island off the southern Italian coast, where astronomers reported several new sightings, including the first evidence of another multiplanet system around a sunlike star. And with the total steadily growing, researchers are beginning to identify tentative groupings of planet types, one of which, says Geoff Marcy of San Francisco State University, is "a class of planets that is completely unlike the planets in our solar system."

Exoplanets cannot be seen directly, but betray their existence by the gravitational pull they exert on their parent stars—which wobble toward and away from us. By measuring these regular variations in the star's velocity, astronomers can deduce the orbital period of the planet and put a lower limit on its mass. Soon after Michel Mayor and Didier Queloz of the Geneva Observatory in Switzerland announced their discovery of a massive planet orbiting a star known as 51 Pegasi (*Science*, 20 October 1995, p. 375), Marcy and his colleague Paul Butler discovered two more: one around 47 Ursae Majoris and another at 70 Virginis (*Science*, 26 January, p. 449). Now at least 10 exoplanets are known to be orbiting sunlike stars, and some general trends are beginning to emerge.

The first is that planets less massive than five times the mass of Jupiter tend to have circular orbits, while larger stellar companions—more than nine Jupiter masses—reside in elliptical orbits. "This might provide us with a clear distinction between true planets and brown dwarfs," says Mayor. Brown dwarfs are "failed stars" which are not massive enough to ignite hydrogen fusion in their cores. Mayor announced at Capri his discovery of three new brown dwarf companions, and he and others suggested that the companions of 70 Virginis and HD 114762 should be reclassified as brown dwarfs.

Within the group of less massive companions in circular orbits, astronomers have been surprised to find a completely new class of planets, which they dubbed "hot Jupiters." These giant planets are termed hot because their orbits are between 10 and 20 times closer to their parent stars than the Earth is to the sun, and their orbital periods—or "years"—are only a few days long. The original exoplanet, around 51 Pegasi, belongs to this class, and three more have since been discovered orbiting 55 Cancri, Tau Bootis, and Upsilon Andromedae, Marcy and Butler's most recent find. "55 Cancri and Tau Bootis are close cousins of 51 Pegasi, while Upsilon Andromedae is a real twin," says Marcy. Within a couple of months Mayor expects to announce four new members of this class, based on observations that are currently being analyzed.

Theorists are completely puzzled by these findings—current models cannot account for giant planets forming so close to their parent stars. Some conclude that the hot Jupiters must have formed at much larger distances and subsequently migrated inward as they were slowed down by friction with a remnant circumstellar disk of gas and dust (*Nature*, 18 April 1996, p. 606).

But Mayor is not so sure. If orbital decay is the culprit, something is needed to halt this process after the planet has traversed nearly 99% of its original distance to the star, he says, for that is where all the hot Jupiters are being found. Some theorists, including Jack Lissauer of the State University of New York, Stony Brook, are working on new models to explain the existence of the hot Jupiters. Lissauer thinks his computer simulation might be able to form the planets at their current positions, but says he has to do more calculations before giving details about his hypothesis.

Next year, Marcy and Butler will use the 10-meter Keck telescope in Hawaii for their planet-hunting program, while Mayor and Queloz will have moved to a dedicated telescope at the European Southern Observatory in Chile. With these better telescopes, more sensitive detectors, and more observing time, the two groups expect to discover full-fledged planetary systems instead of single planets. The Capri meeting provided a possible taste of things to come when Butler announced that he and Marcy had detected a second planet orbiting 55 Cancri. Also, a few weeks before the Capri meeting, George Gatewood of the Allegheny Observatory in Pittsburgh announced his discovery of two planets in orbit around a nearby star called Lalande 21185 using a different detection technique. Most astronomers have few doubts that exoplanets will soon vastly outnumber Earth and our eight nearby companions.

–Govert Schilling

Govert Schilling is an astronomy writer in Utrecht, the Netherlands.

PLANETS DISCOVERED AROUND OTHER SUNLIKE STARS

Star	Distance to star (Earth-Sun = 1)	Orbital period	Lower limit on mass (Jupiter = 1)	Notes
51 Pegasi	0.05	4.3 days	0.5	First exoplanet, "hot Jupiter"
47 Ursae Majoris	2.1	1103 days	2.4	
70 Virginis	ecc. orbit	116.7 days	6.6	Possible brown dwarf
55 Cancri	0.11	14.76 days	0.8	"Hot Jupiter"
55 Cancri	>5	unknown	>5	
HD 114762	ecc. orbit	84.01 days	10	Possible brown dwarf
Tau Bootis	0.0047	3.31 days	3.7	"Hot Jupiter"
Upsilon Andromedae	0.054	4.61 days	0.6	"Hot Jupiter"
Lalande 21185	2.2	5.8 years	0.9	Astrometric detection
Lalande 21185	11	30 years	1.1	Astrometric detection (uncertain)