PLANETARY SCIENCE

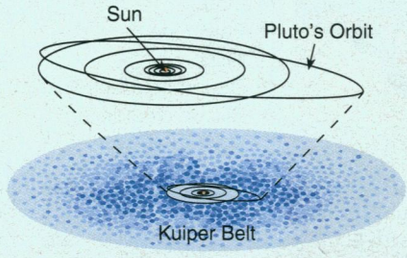
Home of Planetary Wanderers Is Sized Up for First Time

"Scientists Find Source of Comets," shouted the headline on the front page of *The New York Times* last week. The story went on to explain that "in yet another proof of the Hubble Space Telescope's powerful optics, astronomers have detected a reservoir of icy, comet-size objects on the fringes of the solar system just beyond the outermost planets." But, in fact, the *Times* story and similar articles in other newspapers gave the Hubble too much credit—and their ground-based counterparts too little.

Ground-based astronomers have been studying that distant comet reservoir, called the Kuiper Belt, since 1992, when University of Hawaii astronomer David Jewitt and his colleague Jane Luu of Harvard University detected its first members with what is now considered a modest-sized mountaintop telescope. But although there may be no dazzling new Hubble discovery to herald, the space telescope can still claim to have answered a question that has lingered since the Kuiper Belt's discovery: Is it really populous enough to be the home of most of the comets darting through the inner solar system?

The answer from Hubble, with support from ground-based observations, seems to be yes. Between them, they have found nearly 60 Kuiper Belt objects, with Hubble bagging those in the 6- to 12-kilometer size range typical of comets and ground-based telescopes spotting rarer, larger ones—monster comet nuclei hundreds of kilometers across. "It's very clear we're detecting comets in their native reservoir," says Alan Stern of the Southwest Research Institute, a member of the Hubble team headed by Anita Cochran of the University of Texas, Austin. The cometary nursery seems populous enough to account not only for the comets most commonly seen from Earth, but also for many odds and ends of the solar system, including "asteroids" that have turned out to be huge comets—and perhaps even the planet Pluto.

Reported last week at the American Astronomical Society meeting in Pittsburgh, the Hubble observation of distant comet nuclei as small as those seen blazing near the sun "is a moment of real closure," notes Stern. It was 45 years ago that the late Gerard Kuiper theorized that the process of planet formation, in which small chunks of ice and rock called planetesimals accreted to form planets, may have fizzled out beyond Neptune. The result, Kuiper proposed, was a swarm of leftover planetesimals lingering beyond the farthest planets.



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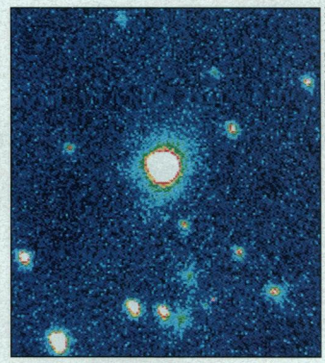

D. JEWITT AND J. LUU

A Kuiper wanderer. Chiron *(right)*, a huge comet orbiting near Saturn, originated in the belt of icy bodies that lies beyond Neptune *(above)*.

The idea lapsed into obscurity, but in 1988, computer modeling of the origin of short-period comets—those that return to the inner solar system every 200 years or less—revived it by pointing to the need for a parent swarm of small, icy bodies just where Kuiper had proposed it (*Science*, 18 March 1988, p. 1372). Four years later, Jewitt and Luu found a 280-kilometer body orbiting 6.1 billion kilometers from the sun (*Science*, 25 September 1992, p. 1865). Their discovery of a second object a few months later confirmed the existence of the Kuiper Belt (*Science*, 9 April 1993, p. 158).

No one knew, however, whether the Kuiper Belt contained enough objects to replenish the population of known short-period comets—currently about 120—as they are winnowed by the sun's heat and collisions with the planets. After all, celestial dynamicists estimate that something like 1 billion to 10 billion Kuiper Belt objects would be needed to make up for the expected loss of one member of the comet population every few years.

Jewitt and Luu and the Hubble team approached this problem of gauging the Kuiper Belt's population from opposite directions. The ground-based team used the 2.2-meter telescope on Hawaii's Mauna Kea to find more bodies in the 100- to 400-kilometer size range, glimpsing an additional seven by 1994; other ground-based observers have added to the total. In the April *Astronomical Journal*, Jewitt and Luu say the seven objects they found in searching a small slice of the sky imply that the inner part of the Kuiper Belt likely contains about 35,000 objects larger than 100 kilometers. Most comets aren't this big, but smaller objects should vastly outnumber large ones in the Kuiper Belt, notes Luu. Extrapolating from these large objects, she finds "that's enough [small objects] to supply the short-period comets."

The Hubble team, hoping to avoid risky extrapolations from larger objects, searched for these small objects directly. In a far smaller area of sky than the ground-based survey had studied, Hubble found 29 Kuiper Belt objects. This approach allowed the group to estimate that 200 million objects this size populate the inner Kuiper Belt. "It all seems to hang together reasonably well" in explaining short-period comets, says Martin Duncan of Queens University in Kingston, Ontario, a Hubble team member.

The same goes for some other solar-system inhabitants. Take Pluto. Smaller than Earth's moon and following an inclined and elongated orbit, it has long seemed a most peculiar planet. Most likely, astronomers hypothesize, it was an especially large planetesimal that escaped being swept up by Neptune and became locked in an orbital ballet in which the two planets stay out of each other's way even though Pluto's orbit at times carries it inside Neptune's. The abundance of leftover solar-system building blocks now makes that scenario look more plausible, says Jewitt—as does the fact that a half dozen of the 26 Kuiper objects detected from the ground seem to follow Pluto-like protected orbits. Other Kuiper bodies have probably been caught in stable orbits as planetary satellites—Neptune's Triton and Saturn's Phoebe, for example.

Not all Kuiper objects are snared on their way in. Others gradually migrate inward past Neptune; once strongly disturbed by the gravity of a giant planet, they plunge toward the sun as a comet. Astronomers have spotted only a few of these icy invaders, the first being Chiron, a 150- to 200-kilometer object discovered in 1977 orbiting between Saturn and Uranus. At first listed as an errant asteroid, Chiron has since shown its true colors—it's a huge comet gently spewing gas and dust. The new evidence for a populous Kuiper Belt implies that Chiron is not as unusual as it looks, Duncan says, who estimates the size of the invading force at roughly a million. "Chiron is probably just the first discovered and the largest example" of a Kuiper object going astray, he says.

Within the next million years, Chiron itself could become a short-period comet and venture as close as an astronomical unit or two from the sun—as close as Earth. Seared by sunlight, "Chiron would be an absolutely fantastic show," says Duncan.

–Richard A. Kerr