were at the beginning of the simulation. Duncan and his colleagues suggest that the gravitational pull of exceptionally large comets within the belt might stir it up enough from within. Additionally, Neptune might be pulling in a trickle of comets whose closest approaches just bring them within Neptune's influence.

Another problem is the need for a belt that is massive enough to supply the comets but not so massive that it unduly perturbs the rest of the solar system. Perhaps the most sensitive indicator of an unseen perturber would be the orbital motion of Halley's Comet, which spends most of its 76-year orbit in the vicinity of Neptune's orbit. Donald Yeomans of the Jet Propulsion Laboratory has calculated that a comet belt at 40 astronomical units having a total mass equal to that of Earth, a modest size for the hypothesized belt, would have twisted Halley's orbit a few thousandths of a degree from the position predicted assuming there were no belt. No such perturbation was detected this time around, notes Yeomans.

A close-in belt of 1 Earth mass is "most inconsistent with what Halley's orbit has been over the past several centuries," says Yeomans. "If you want to move the belt, say out to 100 astronomical units, that constraint goes away."

These problems would become academic if someone caught a glimpse of the belt itself. One member of the belt may already be known. Chiron is an oddball member of the solar system, as black as a comet nucleus, as big as a large asteroid, and orbiting between Saturn and Uranus in an unstable orbit. If there are 100,000 comets inside the orbit of Uranus, as the simulations suggest, and if they have a reasonable range of sizes, "the existence of an object as bright as Chiron inside the orbit of Uranus is not surprising," writes Duncan. Only one in a hundred thousand members of the belt need be as large as Chiron for there to be at least 10,000 belt comets of magnitude 22, which could be detectable.

As Tremaine points out, with that many objects near the ecliptic, the element of chance is removed. An observer can concentrate on detecting faint objects in one small area without worrying whether he picked the right spot. "There's a fairly good chance that with a concerted effort something can be found," says Tremaine. One search is already under way, others are being considered. The Hubble Space Telescope, scheduled for launch in 1989, would greatly simplify the search. ■ RICHARD A. KERR

ADDITIONAL READING

M. Duncan, T. Quinn, S. Tremaine, "The origin of short-period comets," *Astrophys. J. Letts.*, in press.

Fermat's Theorem Proved?

For the first time in memory, the mathematics community is optimistic that its most famous open problem—Fermat's Last Theorem—may finally have been proved. Experts are poring over a proof recently completed by Yoichi Miyaoka of the Tokyo Metropolitan University, currently at the Max Planck Institute for Mathematics in Bonn, West Germany. Although no one will be completely confident until all the details have been thoroughly checked, those involved feel that Miyaoka's proof has the best chance yet of settling the centuries-old problem. Until recently, serious mathematicians have shied away from working directly on Fermat's Last Theorem—it was considered quixotic to be working on a 350-year-old problem.

Fermat's Last Theorem asserts that the equation $x^n + y^n = z^n$ has no positive integer solutions x,y,z if the exponent n is greater than 2. French mathematician Pierre Fermat stated this "theorem" around 1637 in the margin of a book, with the tantalizing remark that the margin was too narrow to include the proof. Mathematicians have been trying to widen that margin ever since. Fermat himself did actually write down a proof of the theorem for the exponent $n = 4$, and Leonhard Euler contributed a proof for $n = 3$. In the 1840s, Ernst Eduard Kummer set up a mathematical theory that enabled him to prove the theorem for a large number of exponents. By last year improvements on Kummer's work, and high-speed computers, had enabled mathematicians to prove Fermat's Last Theorem for all exponents up to 150,000. Furthermore, it has been shown that counterexamples would have to be extremely large, with x, y, and z each having hundreds of thousands of digits.

Mathematicians are optimistic for Miyaoka's proof, in part because it is based on new ideas taken from a previously untried source: differential geometry, a branch of mathematics best known as the setting for General Relativity. In the 1970s, S. Arakelov and other mathematicians in Russia began the task of making arithmetical analogues of results in differential geometry. Their ideas reached a milestone in 1983, when Gerd Faltings, now at Princeton University, developed them into a proof of another important problem in number theory known as the Mordell conjecture. (The Mordell conjecture is much younger than Fermat's Last Theorem; it was formulated in the 1920s.) One consequence of Faltings's result is that the Fermat equation has only a finite number—presumably zero—of different solutions x,y,z for any given exponent n. (In the theory, two solutions are considered the "same" if one is merely a multiple of the other, such as 3, 4, 5 and 6, 8, 10 for $n = 2$.) Faltings's coup led mathematicians to think that many old problems in number theory and algebraic geometry might be accessible to the new methods.

Miyaoka's work involves the arithmetical analogue of one of the deepest results in differential geometry: a fundamental inequality involving certain topological invariants of surfaces. (A simple example of a topological invariant is the number of "holes" or "handles" on a surface, such as the hole in a doughnut and a handle in a coffee cup.) This inequality was proved true in 1974—by Miyaoka, who is a recognized expert in differential geometry. (This is one reason why mathematicians are taking his work on Fermat's Last Theorem seriously.) The connection of the inequality with Fermat's Last Theorem was made about a year ago by A. N. Parshin, a Russian mathematician, who proved that if the arithmetical analogue of the inequality is true, then Fermat's Last Theorem is also true. In other words, Fermat's Last Theorem would be a simple corollary to a much deeper theory. Miyaoka has now apparently put on the crowning touch by proving the arithmetical analogue of his own inequality, thus completing Parshin's argument.

Tempering their optimism, mathematicians also express caution at this point. Experts in the new theory are only now starting to check Miyaoka's proof, and it may take weeks or even months for the theorem to be accepted with confidence. In a sense the proof is like a carefully thought-out, very complicated computer program that has not been run very often—the logic looks good, but there may still be bugs. However, even if mistakes are found to invalidate Miyaoka's proof, the basic approach is considered promising. ■ BARRY A. CIPRA

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