

# Jupiter Bombardment Now Certain, but How Big a Show?

When astronomers announced in May that a shattered comet might be on a collision course with Jupiter, the skimpy observations of its movements then available left some doubts. But now the fate of Periodic Comet Shoemaker-Levy 9, which Jupiter's gravity tore into at least 21 pieces during a close encounter last summer, is certain: impact ahead. Less certain, however, is how dramatic that event will be.

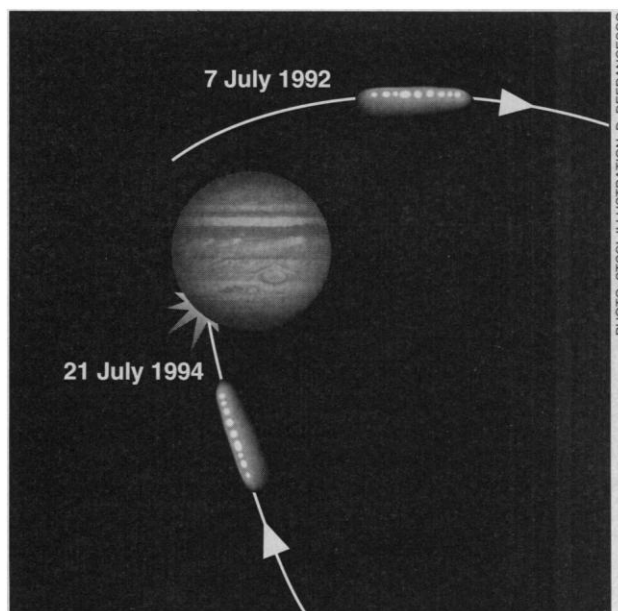
Additional observations tracing the comet's highly elongated orbit about the planet make it plain that the next time around, what remains of Shoemaker-Levy—whose dramatic images resemble “pearls on a string”—will not escape collision. “We’re very confident that almost all, probably all, of the parts will hit [Jupiter]” around 21 July of next year, says orbital dynamist Donald Yeomans of the Jet Propulsion Laboratory.

If the chunks of Shoemaker-Levy are as large as some astronomers think, their impacts should put on a riveting celestial display that already has researchers lining up for observing time. Even though the comet fragments are expected to fall on the backside of Jupiter, spacecraft across the solar system should glimpse the explosions, and lingering effects on the planet would likely be obvious after the impact sites rotate into view—a boon to researchers interested in everything from impact dynamics to the composition of Jupiter's interior and the makings of Jovian weather. But all that would be threatened if estimates of the size of the fragments, estimates that have already been halved, shrink much further. Says astronomer Harold Weaver of the Space Telescope Science Institute: “Nobody can predict it won’t be a dud.”

In early June researchers were talking about the possibility of a truly spectacular event, in the range of billions of megatons—“the most spectacular astronomical event ever to be witnessed in the heavens during recorded history,” as Clark Chapman of the Planetary Science Institute in Tucson put it in a commentary in *Nature*. That prospect was based on a speculation by astronomer and impact specialist Eugene Shoemaker of the U.S. Geological Survey in Flagstaff, a co-discoverer of Shoemaker-Levy.

Shoemaker had suggested that the dust shrouding the comet's multiple nuclei since the breakup might be thin. If that were the

case, the bright central cores of the “pearls” seen in telescopic images were the nuclei themselves shining through, not just the cores of dust clouds. And if so, Shoemaker figured, the largest fragment could be about 10 kilometers in diameter. That speculation led to the early, dramatic estimates of the magnitude of a potential impact—including comparisons with the impact 65 million years ago



**The big guy wins.** Last summer Jupiter broke up comet Shoemaker-Levy. Next summer the two will collide.

that formed the 180-kilometer crater now buried beneath the Yucatan Peninsula and that may have wiped out the dinosaurs.

But since then, size estimates for the comet fragments have fallen, and the predicted magnitude of the largest impact is down almost 10-fold. Even Shoemaker has lowered his expectations, now that the Hubble Space Telescope (HST) has given astronomers a better look at the comet nuclei. In a notice on an electronic bulletin board devoted to Shoemaker-Levy, Weaver and 18 colleagues, including Shoemaker, report that they used Hubble images acquired 1 July to estimate how much of the light from Shoemaker-Levy is from dust and, by subtraction, how much comes from the nuclei themselves. According to their analysis, the largest fragment is no larger than 5 kilometers—an eight-fold reduction in mass and thus in impact energy.

The HST upper limit may be refined by further analysis and new observations scheduled for 28 July, but Shoemaker doesn't think

Shoemaker-Levy will shrink much further. “I don’t think the nuclei will be a whole lot smaller” than 5 kilometers, he says. The largest “may be 4 kilometers, but it certainly isn’t 1 kilometer. I don’t think these things are going to be swallowed without a trace.”

Other astronomers aren’t so confident. Michael A’Hearn of the University of Maryland, also a member of the HST team, says that the largest fragment “could be a lot less” than 5 kilometers. “A factor of 5 [decrease] has happened in the past, and I wouldn’t be surprised if it happened again.” And Weaver adds that “1 kilometer is in the realm of possibility.”

If the size holds anywhere near 5 kilometers, the final 216,000-kilometers-per-hour encounter of Shoemaker-Levy and Jupiter should still be spectacular. Planetary physicist David Stevenson of the California Institute of Technology has made some calculations that he says are “quite crude, but intended to make people aware how extraordinary this event could be.” He calculates that pressure building in front of a falling 6-kilometer body would crush it perhaps 100 kilometers below the tops of Jupiter’s clouds. At that point, the comet’s kinetic energy, converted by friction into heat, would vaporize the nucleus, creating a blue-white fireball 150 kilometers across—a 25 million megaton explosion. That detonation would blow a hole in the atmosphere, while the fireball’s heat would slowly loft a thousand-kilometer-wide plume from the deep atmosphere. “That could conceivably be like the Great Red Spot,” says Stevenson. The smaller comet fragments would only add to the fireworks.

The prospect of a show like that is spurring observers to line up telescope and spacecraft observing time for next July. At least one of the two Voyager spacecraft, which are now leaving the solar system, should be able to turn a few instruments back toward Jupiter, and Shoemaker hopes that a Voyager camera can be reactivated for the occasion. The Galileo probe will still be 17 months from its arrival at Jupiter, but from its vantage point the impacts could be just in view.

Still, a good vantage won’t help much if the largest fragment is closer to 1 kilometer in size than 5 kilometers, which would reduce the impact energy by another two orders of magnitude. Barring some revelation from an unforeseen quarter, the best chance to learn whether the show will be as good as billed may come next spring, after the scheduled in-orbit repair of HST. Astronomers are keeping their fingers crossed that the space shuttle repair mission can stay on schedule. Shoemaker-Levy certainly will.

—Richard A. Kerr