■ SCIENCE

COLLISION COURSE

Jupiter is about to be walloped by a comet. The cataclysmic explosion will serve as a warning to Earth: It could happen here.

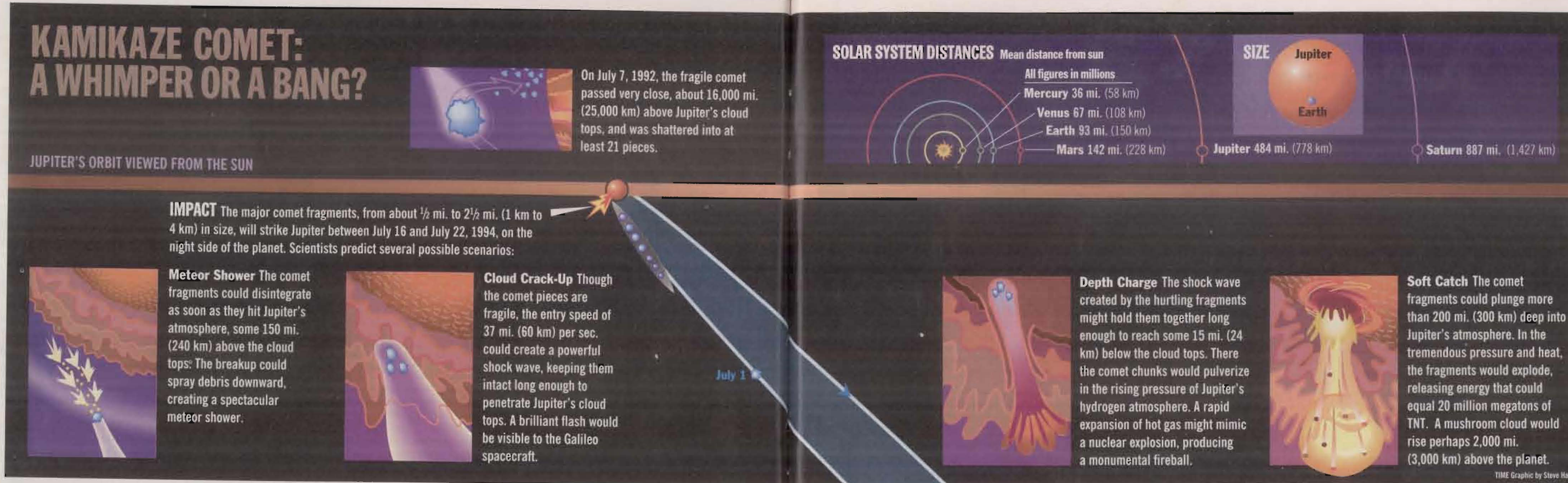
By JAMES RESTON JR.

ON JULY 16, A CHUNK OF INTERstellar debris the size of a mountain will smash into the largest planet in the solar system. And that will be only the beginning of the most violent encounter humanity has ever witnessed. Over the following six days, more chunks—some perhaps 2.5 miles in diameter—will smack into Jupiter, one after another, in a barrage as predictable as a round of automatic gunfire. The agent of destruction: an icy comet, long held captive by Jupiter's gravity, that has broken up into a fleet of 21 natural megabombs.

They may blow apart high in the Jovian atmosphere. Or perhaps they will hold together long enough to reach the dense gases that form Jupiter's surface. They will be traveling phenomenally fast: 37 miles a second. If they do stay intact, they will plow deep—15 miles, perhaps even 250 miles—into the gaseous soup.

The resulting explosions will defy comprehension. While the largest hydrogen bomb ever detonated in the earth's atmosphere was the Soviet

SMASH HIT Split into at least 21 mountain-size pieces, the comet will steadily bombard the planet over a period of six days



Union's 58-megaton blast in 1961, the combined energy of the 21 explosions on Jupiter could reach 20 million megatons. The comet, named Shoemaker-Levy 9 for its discoverers, may unleash a mushroom cloud that rises to a height of 1,500 miles into the Jovian atmosphere. For several hours at least, the giant planet may resonate like a bell. For observers on Earth, it may appear to glow with twice its usual brilliance.

Those observers—and they will be legion—will enjoy a unique opportunity to watch the kind of event that helped shape the solar system and continues to sculpt its features. Collisions with comets and rocky asteroids—the two kinds of small bodies found orbiting the sun—helped create the planets in the first place. Subsequent collisions have also left their telltale marks: the moon, Mercury and other planets including the earth itself are pocked with craters that were almost surely stamped by incoming comets and asteroids.

Humans may owe their very existence to colliding comets, which are essentially dirty snowballs of ice and other frozen gases trailing long tails of debris. A comet landing on a lifeless world may have contributed the molecules that made living creatures possible. Earth's oceans may have been produced in part by a watery invader from outer space. We may also eventually owe our destruction to these celestial travelers. Many scientists believe it was the crash of a giant comet that killed off the dinosaurs and many other terrestrial species some 65 million years ago.

FOR MONTHS, ASTRONOMERS have been arguing over what sort of legacy will be left by this encounter. Among the more dramatic possibilities: Jupiter may gain a Saturn-like ring. The fifth planet already has a faint ring, first detected by Voyager 1 in 1979. But if July's impacts blow a significant hole in the Jovian atmosphere, huge amounts of debris could escape and thicken that ring over the next several years, perhaps making it visible to Earth's telescopes.

Another intriguing possibility: Jupiter, now a cyclops with its distinctive Great Red Spot for an eye, may gain a second eye. The spot is believed to be a kind of permanent, counterclockwise cyclone. If the collisions unleash enough energy, they might stir up a similar maelstrom elsewhere on Jupiter's surface.

Whatever the visible consequences, this summer's events will provide an unprecedented opportunity for learning. Never before have humans been able to predict an impact in our own solar system and mobilize the full resources of science to watch and measure the effects. Virtually every major telescope on this planet will be trained on our distant neighbor. Since the comet pieces will hit the far side of Jupiter, only the space probe Galileo, which is headed past the planet, will have a direct look. But given Jupiter's swift rotation, the site of each explosion will whirl into view about 10 minutes after impact.

Many of those watching are hoping to glean some insight into the nature of Jupiter's interior, which has been perpetually shielded by clouds. Quite possibly the comet fragments will cause the planet to eject material from this long-hidden interior in what will amount to a giant belch. Scientists also hope to detect, deep within the planet, hydrogen in a liquid metallic form.

Some of the scientific interest in the collisions is pragmatic. For decades, nuclear-weapons experts have been building secret computer models of vast explosions, using confidential "shock physics codes." With Shoemaker-Levy 9, they can witness a real rather than an imaginary blast. The collisions present a unique opportunity to validate their theoretical mathematics.

There is also a distinctly vicarious tinge to the earthly interest in Jupiter's plight. Will a similar cataclysm happen on Earth, as it apparently has in the past? And if our globe were thus threatened, what could we do about it? To damage the famous phrase of the 16th century English writer who was meditating upon the condemned as they went to the scaffold: "But for the grace of God there goes Earth."

THE DISCOVERY. Around midnight on March 23, 1993, astronomers Eugene and Carolyn Shoemaker stood with their collaborator, David Levy, outside the Schmidt telescope at Palomar Observatory, looking disconsolately at the cloudy sky. It was as if nature were toying with them. Through January and February, the weather had been terrible on the mountain near San Diego, California, and they had been skunked in their latest program to search for undiscovered comets and asteroids.

Briefly, the clouds seemed to thin, and Levy, ever the optimist, wondered aloud whether there were a few more sheets of the damaged film that had been slightly exposed by accident back at the Shoemakers' home base in Flagstaff, Arizona. Levy was always ready to observe, against the stiffest odds. But in a mom-and-pop operation like their Mount Palomar Asteroid and Comet Survey, the Shoemakers had to watch the bottom line. Good film like theirs cost $4 a sheet. "If we don't get anything, it won't be any great loss," Levy insisted, pointing out that the exposed film might be worthless anyway. Reluctantly, the Shoemakers indulged their enthusiastic partner and returned to the 18-in. telescope for a few desultory shots through the clouds.

A graduate of Caltech and Princeton, and a winner of the National Medal of Science, Gene Shoemaker, 66, has made a career out of tracking down asteroids and comets while working for the U.S. Geological Survey. In 1982 his wife Carolyn, now 64, joined him as an unpaid partner. She has proved to be particularly adept at the painstaking process of examining the tiny dots of light in a telescopic picture. Using analytical techniques devised by her husband, she had already discovered 28 comets, the world record.

David Levy, 45, is no slouch either, even though he is sometimes patronized as an amateur. An author and columnist for *Sky & Telescope*, he is credited with discovering eight comets and co-discovering 13 others—many with the modest 8-in. Schmidt in his Tucson, Arizona, backyard.

In his collaboration with the Shoemakers, Levy is the romantic. A Canadian by birth, tall and wide-eyed, he came to astronomy by way of English literature and Gerard Manley Hopkins, particularly a poem fragment Hopkins wrote as American astronomer Horace Tuttle observed Tempel's comet in 1864:

I am like a slip of comet
Scarce worth discovery, in some corner seen
Bridging the slender difference of two stars …

After writing a master's thesis on Hopkins at Queen's University in Kingston, Ontario, Levy gravitated to Tucson, where astronomers are numerous and the night viewing superb. He describes his passion—comet hunting—as "a bit of art, a bit of sport and occasionally science."

It seemed mostly frustration that afternoon on Mount Palomar when he and the Shoemakers prepared to analyze the pictures they had taken on the damaged film. Peering through her stereomicroscope, Carolyn thankfully saw that the film was blurred only slightly around the edge of the plates. As she moved methodically across sections of sky, 60 sq. mi. each, something bizarre and exotic suddenly appeared in a region of space not far from Jupiter. Not a dot but a streak, seeming to levitate out of the picture.

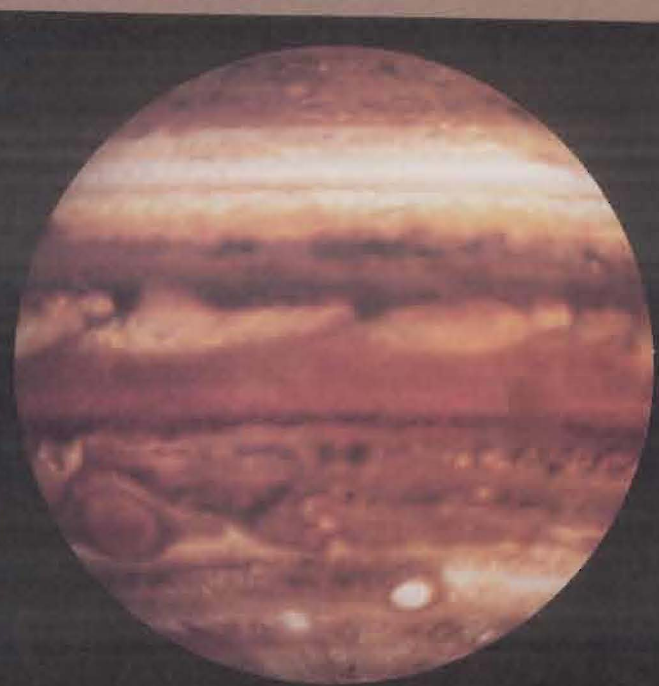
"It looks like a squashed comet!" she exclaimed, as she called Gene over. With his first glimpse, the geologist was uncharacteristically silent. Levy had never seen his partner look so bewildered. The object—if it was an object and not some errant, ghost image—was unique. Bar-shaped, a faint line with a dense tail, it gave Shoemaker an eerie feeling.

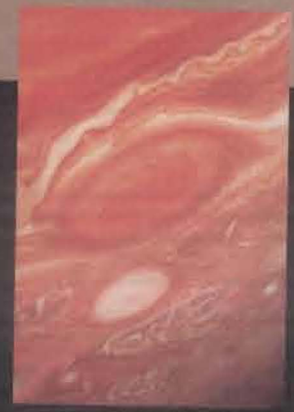
"Are you sure it can't be an asteroid?" someone

JAMES RESTON JR.'s *newest book,* Galileo, *was just published by HarperCollins.*

THE KING OF THE PLANETS

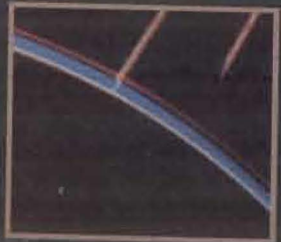
It would take 11 Earths to span Jupiter's 90,000-mile diameter and more than 300 to equal its mass. Yet aside from an Earth-size core of iron and rock, Jupiter is mainly gas—a 37,000-mile-deep blanket of 90% hydrogen and 10% helium. Ammonia and methane lend a striped effect.





JPL—NASA

THE GREAT RED SPOT, first observed by the English astronomer Robert Hooke in 1664, is a giant, counterclockwise cyclone, some 16,000 miles across, sandwiched between two "jet streams" of wind that flow in opposite directions. No one has explained how this and other, smaller Jovian storms arose or how they can persist for so many years.



THE RING, discovered by Voyager 1 in 1979, is about a billion times less dense than the rings of Saturn.

THE MAJOR MOONS are a mismatched set: icy Europa is riddled with cracks; sulfurous Io has active volcanoes; Callisto is deeply carved with craters; and Ganymede bears broad pale bands scored with parallel grooves. Much less is known about the planet's 12 smaller satellites.

asked. It was a good question. If a comet passes by the sun too many times, all its ice may evaporate, leaving behind just rock and dust—an asteroid. But asteroids are dead rock rather than volatile like this phantom, which seemed to have the trademark of comets: a gaseous dust trail.

For nearly an hour they debated. Outside, the infernal clouds had thickened. There would be no way to revisit the region of Jupiter and confirm the discovery, and Levy was worried. The moon was near its dark period, creating prime viewing conditions for astronomers throughout the world. Jupiter was near "opposition," its farthest point from the sun, and there would be many telescopes pointing at the giant planet.

Levy had good reason to fret. In fact, three other groups had caught a glimpse of the streak in the preceding days—groups in Japan, Chile and even at Palomar, using a different telescope. But none had followed up on the sighting. For a discovery to be confirmed, the International Astronomical Union requires exact measurements and observations from two nights. The Shoemaker-Levy claim, if valid at all, had to be reported and established before someone else beat them to it.

So Levy sat down at the computer to send an Internet message to Cambridge, Massachusetts. The recipient was Brian Marsden, whom Levy likes to call "the celestial policeman." As head of the division within the International Astronomical Union that is quaintly called the Central Bureau for Astronomical Telegrams, Marsden has the power to confirm and announce cosmic discoveries beyond the moon and to name the finds after the discoverers. Levy gave Marsden the coordinates of the "strange comet."

For confirmation, Levy called Jim Scotti, an astronomer at the University of Arizona's Lunar and Planetary Laboratory in Tucson who scans the skies with the powerful 36-in. Spacewatch telescope on Kitt Peak. Sometime after midnight, in the course of his own search for Earth-approaching asteroids, Scotti moved his telescope to the spot Levy had specified. Alone on the mountain peak, he watched as an amazing image scrolled onto his computer screen. For 15 minutes Scotti tried to collect his thoughts as he waited for Levy to call back.

"Well, do we have a comet?" Levy demanded from his distant mountain. During the wait, he had put Beethoven's *First Symphony* on a stereo, and the fourth movement was rising to its climax. "Do you have a comet!" Scotti replied. "I've been trying to pick my jaw up off the floor!" When Levy hung up, he turned to the Shoemakers. "We're listening to Beethoven's comet symphony!" he whooped.

Later that night, Scotti wrote his official confirmation of the "remarkable" sight to Marsden in Cambridge: "It is indeed a unique object, different from any cometary form I have yet witnessed. It has the appearance of a string of fragments spread out along the orbit." Scotti's report supported Gene Shoemaker's hunch that the "mother" comet had split into a large number of "daughters." What remained to be seen was where these girls were headed.

DESTINATION JUPITER. It is the giant demon of planets. More than 300 times larger than Earth, it rotates nearly three times faster, making the Jovian day about 10 hours rather than 24. And in many ways, it is the most primitive of planets. Like the sun, Jupiter is believed to be largely a ball of hydrogen and helium, but the gases are cooler and have not ignited to create a nuclear fireball. (Jupiter would have to be 10 times more massive to create the internal pressures that spark fusion, the nuclear reaction that powers the sun.)

Roiling around Jupiter is a squirrel's nest of orbits traveled by comets, asteroids and 16 moons—the most of any planet. The four largest satellites were first observed by Galileo in 1610. It was the existence of these moons, rotating like a mini-solar system around Jupiter, that the great astronomer used to undermine the Earth-centered view of the universe that had been espoused for centuries and sanctioned by the Roman Catholic Church.

The Jovian surface is dotted with "storms" that swirl but do not sway from their positions. By far the largest, the Great Red Spot, was first seen in 1664. Its vibrancy has diminished and intensified over the centuries as if it were the eye of Jupiter's passionate soul. Scientists have Voyager 1 and 2 to thank for much of what is known about the planet, including the presence of two of the smaller moons, its faint ring and the volatile volcanic activity on its moons. But great questions remain: the reason for the cyclones, the colors of the clouds, the nature of the material below the cloud tops. The approaching comet, formally designated as Periodic Shoemaker-Levy 9, may unlock some of those mysteries.

In the days following the discovery of the unusual comet, the first challenge was to calculate its orbit. Using a few crude computations, Marsden quickly figured out that Shoemaker-Levy 9 was orbiting Jupiter rather than following the more usual cometary path around the sun.

Meanwhile, the big telescopes around the world turned toward the exotic formation. Upon close inspection from the 2.2-m reflecting telescope on Mauna Kea in Hawaii, the count of daughters grew from five to 17 and finally to 21, all in a nearly perfect line and all of roughly equivalent size. Far off each end of this "string of pearls" stretched expansive "wings." The wispy contrails gave the comet a certain aerodynamic, if not angelic, quality. Moreover, the procession was spreading out, and there were hints it was still fragmenting.

At the Jet Propulsion Laboratory (J.P.L.) in Pasadena, California, two experts in orbital dynamics, Donald Yeomans and Paul Chodas, took over the job of calculating where Shoemaker-Levy was headed and where it had come from. The comet's early history is largely a matter of informed conjecture. Yeomans and Chodas speculate that the streaming ice ball had wandered aimlessly around the solar system for perhaps 4.5 billion years. Very probably it bounced off the outer atmospheres of the other planets in a kind of pinball game, slowly gaining in size as celestial debris hit and stuck.

ALAN LEVENSON FOR TIME

DISCOVERERS David Levy, left, with Carolyn and Eugene Shoemaker at the 18-in. Schmidt telescope they used to make their greatest find. To Levy, comet hunting is a "competitive sport." The Shoemakers hold the world record.

The comet's recent history is more certain. About a decade ago, it had the misfortune to wander into Jupiter's kingdom, where it was snared, like a careless insect, by the planet's gravity. Following a long, elliptical orbit that brought it as close as 16,000 miles from its captor and as far away as 31,000,000 miles, it circled until July 7, 1992, when it shattered to pieces during its closest approach. The increased surface area and dust created by the breakup meant it reflected more sunlight and thus became visible to the earth's telescopes.

The breakup bore no relation to the popular notion of cosmic explosions, nor was it anything like hitting a rock with a hammer. The fracture, caused by Jupiter's uneven tidal forces, was the gentlest kind of division, more like separating pancakes. The progenitor was so weak, Yeomans decided, that it could have been pulled apart by human fingers. This confirmed what scientists had long believed: comets are extremely delicate. "It is amazing that the solar system could create an object so fragile," says Yeomans, "and that it would stay together for so long."

The expansive wings were still a puzzle. According to J.P.L.'s Zdenek Sekanina, probably the world's expert on split comets, they were formed by the dross of the breakup. This celestial dust consisted of particles ranging in size from pebbles to boulders as large as a house. During the breakup, the particles banged into one another, and the force of the collisions flung them outward. Over time, the gravitational pull of the sun stretched the wings wide.

COLLISION COURSE. In late April 1993, only a month after the discovery of Shoemaker-Levy, the clan of planetary scientists gathered in Sicily to consider the hazard of asteroids colliding with Earth. Edward Teller, famous for helping develop the H-bomb and championing the Star Wars missile-defense program, had been leading a good deal of broad-shouldered talk about using nuclear bombs to blow up menacing space invaders. But the recent fiasco over Comet Swift-Tuttle was fresh in everyone's mind. Some scientists had erroneously calculated a small chance that this 5-mi.-wide comet would smash into Earth in the year 2126. The forecast caused an uproar; then, with rechecking, the estimates were revised: Swift-Tuttle will surely pass by Earth at a safe distance.

Brian Marsden had been involved both in the mistaken warning and in the revision. In Sicily he was in no mood to rile up his fellow astronomers or the public with another sensational prediction. He was alarmed enough one morning at breakfast when Teller suggested that regardless of whether an asteroid or a comet was threatening Earth, scientists should try to blow one up. "Why would you want to do that?" Marsden asked. "To gain knowledge!" Teller exclaimed.

In fact, Teller had been advocating the use of a nuclear device against an asteroid as an "experiment" for two years. Critics said this proposal was merely a make-work program for idle bomb experts in the post–cold war era (half of U.S. astrophysicists are engaged in weapons research). Down the table, a scientist who overheard Teller's remark turned to a colleague and whispered, "If you've got a problem, Eddie's got a bomb!"

In the midst of the Sicily conference, Marsden received a startling E-mail message from a top amateur astronomer in Japan. Shuichi Nakano, an expert in orbital calculations, had run some numbers and concluded that Shoemaker-Levy was on a collision course with Jupiter. Marsden, still smarting over Swift-Tuttle, was not convinced. He sent a telegram to Nakano: "We need more observations." Not until six months—and many calculations—later did Marsden feel confident enough to announce to the world that the collision was a certainty.

WHAT KIND OF IMPACT? Still hotly disputed—and of utmost importance—is the size of the parent comet and its 21 daughters. For the bigger they are, the more cataclysmic will be the event starting on July 16. H. Jay Melosh at the University of Arizona's Lunar and Planetary Laboratory in Tucson calculated that the original comet was perhaps half a mile in diameter; this is the low end of the estimates. The J.P.L.'s Sekanina, meanwhile, estimated that the parent was six miles across and the largest daughter two miles. Unfortunately, the spectacular images taken by the Hubble Space Telescope of the cometary string of pearls have failed to settle the matter. It is just too hard to distinguish the solid core of each pearl from its veil of sparkling dust.

Forecasters trying to gauge the force of the impending collisions have had to use their best guess. Most have chosen a conservative 1-km (about half a mile) diameter for the comet fragments. Regardless of the size, the theorists agree that the amount of energy to be poured into Jupiter's atmosphere in July far exceeds the megatonnage of the world's nuclear arsenal, and probably amounts to hundreds of times more energy than was released in the calamity that supposedly killed the dinosaurs.

Assuming that Jupiter will be wracked by one explosion after another, J.P.L.'s Glenn Orton predicts that because of the reverberating shock waves, "the whole planet will ring like a bell." Others are inclined to understatement. At the University of Chicago, Mordecai-Mark Mac Low compares the impact of Shoemaker-Levy to sticking 21 needles into an apple: "Locally, each needle does significant damage, but the whole apple isn't really modified very much."

But what will the impact look like? Will there be a huge mushroom cloud, a glorious meteor shower, a diamond-like flash, a huge ripple in Jupiter's clouds ... or nothing at all? Using various methods, scientists are coming up with different predictions. Four distinct scenarios are put forward:

• Meteor shower. The large fluffy fragments could begin to disintegrate as soon as they hit Jupiter's upper atmosphere, about 150 miles above the cloud tops. Such a breakup would spray debris downward in a shotgun blast. This version offers the hope that Earth observers may be able to witness the beginning of the process directly over the curve of Jupiter's horizon. Says J.P.L.'s Yeomans: "This could be one hell of a meteor shower."

• Crack-up in the clouds. Regardless of how fragile the comet pieces are, the entry speed of nearly 40 mi. per sec. will create a shock wave. If the fragments are on the small side, the wave could hold them together until they reach the cloud tops, where they would disintegrate.

• Depth charge. This scenario accepts the holding power of the shock wave and takes the comet about 15 miles below the cloud tops. There the comet chunks would pulverize in the rising pressure of Jupiter's hydrogen soup. A rapid expansion of hot gas would mimic a nuclear explosion, and a monumental fireball could develop so quickly it would literally blow a hole in the Jovian atmosphere.

• Soft catch. Given the enormous explosion that this scenario promises, its label is something of a misnomer. Developed by Thomas Ahrens of Caltech, this highly disputed theory assumes the comet fragments to be ice projectiles, or balls of "crushed ice." They would plunge into Jupiter's atmosphere much as a softball would enter a large feather pillow. But they would swiftly penetrate as deep as 200 miles into the gaseous and liquid interior, creating a dramatic show: a mushroom cloud rising 1,500 miles high, a flash making Jupiter twice as bright as normal, and an atmospheric vortex that will last 100 years.

Only Ahrens predicts that Earth observers will be able to witness the explosions directly. He thinks the effects will last longer than the 10 minutes it will take for the impact sites to rotate into view. As Ahrens talks up the "marvelous possibilities," even astronomers who think he is wrong quietly hope he's right.

ALL EYES ON THE HEAVENS. The mobilization in the astronomy community for the Shoemaker-Levy collisions is sometimes referred to as an "observational campaign," and the preparations have taken on Normandy-like proportions. "Every major telescope in the world is going to be pointed toward Jupiter that week," says Michael A'Hearn of the University of Maryland, who runs an electronic bulletin board on Shoemaker-Levy. Radio waves will be monitored; the infrared and ultraviolet spectrums watched; heat, sound, color and pressure measured. Airplane and space observatories as well as portable telescopes will be deployed.

Regrettably, it will be a lousy show from the U.S. Only with the impact of the second fragment, in the early morning of July 17, will Jupiter be situated for good viewing from the darkened eastern U.S. Better off is southern Africa. William Hubbard of the University of Arizona will be taking his portable 14-in. telescope to the French island of Réunion, off the coast of Madagascar. There, with good luck, he hopes to view Jupiter for seven of the impacts. His colleague Jim Scotti will be at the Wise Observatory in Israel, poised to witness four impacts. There Scotti will use an instrument called a chronograph to darken the disk of Jupiter and follow the comets until they disappear to their fate behind the horizon only seconds before impact.

Amateur astronomers will play an important role. Some plan to focus on the moons of Jupiter and even on its faint ring, hoping to see the flash of the explosion in its reflected glory. Steve Lucas, an expert supernova watcher when he is not driving his 18-wheeler out of Chicago, has put the word out to his national network of amateurs: familiarize yourself with the features and cloud formations of Jupiter in the weeks before the collision so you can detect any changes during the critical week.

Yeomans and Chodas at J.P.L. will provide in advance the times of each impact. Their data will be transmitted around the globe through computer networks. By early July the J.P.L. scientists will be ready to predict the time of first impact within a few minutes.

THE CLOSEST OBSERVER OF all will be the Galileo spacecraft, now speeding toward a perch 150 million miles from Jupiter at the time of collision. Its view will be direct but its reactions deliberate. Crippled by mechanical problems, Galileo can take a picture only every 2.3 seconds, and its transmissions back to Earth will be painfully slow. These pictures may not be processed for months.

For all the anticipation, the nightmare of Comet Kohoutek haunts the generals in the Shoemaker-Levy campaign. That comet was supposed to provide the show of the century in 1973, and astronomers wallowed in the glory of advance publicity. To their profound embarrassment, it turned out to be hard to see and something of a joke. "Kohoutek is very much on our minds," says Chicago's Mac Low. "With its huge uncertainties, Shoemaker-Levy could be a fizzle. We may see nothing."

LESSONS FROM CATASTROPHE. The sky watchers will be busy for decades pondering the meaning of their observations. Is there water vapor in Jupiter's clouds? If a permanent cyclone is created by Shoemaker-Levy, would that explain the origin of the Great Red Spot? If Jupiter's ring thickens, could comet collisions also account for Saturn's rings? But even before it strikes Jupiter, Shoemaker-Levy has solved a few scientific puzzles. Besides confirming that the tensile strength of a comet is about 1,000 times as weak as that of a soufflé, it also explains bizarre features on the surfaces of our moon and several satellites of Jupiter. For 30 years lunar geologists have been puzzled by a string of equal-size craters called the Davy catenae. Voyager 2 photographed similar chains on two of Jupiter's moons, Callisto and Ganymede. Now, notes Melosh, it seems likely the crater chains were carved by such splintered comets as Shoemaker-Levy.

But scientific questions should not overwhelm our awe at the power of the event itself. For the drama of Shoemaker-Levy lies in the mind and in the imagination, where it can be projected as a dilemma for our own planet. If such a comet train hit one of Earth's oceans, tidal waves would deluge and destroy the closest coastlines. If it hit land, it could incinerate whole countries and kick up a cloud of dust that would blot out the sun and bring on nuclear winter. Millions, perhaps billions, of people would die.

David Levy hopes his fellow earthlings will pause to consider not only the frightening possibilities but also the sheer grandeur and scope of the forces at work in the universe. "We are going to be party to a great event," he says. "If you said to Galileo, 'What will you learn by looking at the moons of Jupiter?' he would answer, 'I don't know, but I'm sure going to be there tomorrow night to look at them.'" ■

OMENS FROM ON HIGH

Halley's comet in 1910

SPL—PHOTO RESEARCHERS

LONG BEFORE HUMANS KNEW THAT COMETS POSED A THREAT TO THIS and other planets, they viewed the appearance of these celestial streakers as omens of danger or a change in fortune, or as a message from the gods. Some notes from the history of comets:

COMET OF 1059 B.C. Dubbed a "broom star" by Chinese astronomers, the first recorded comet flashed by during a battle between rival kings.

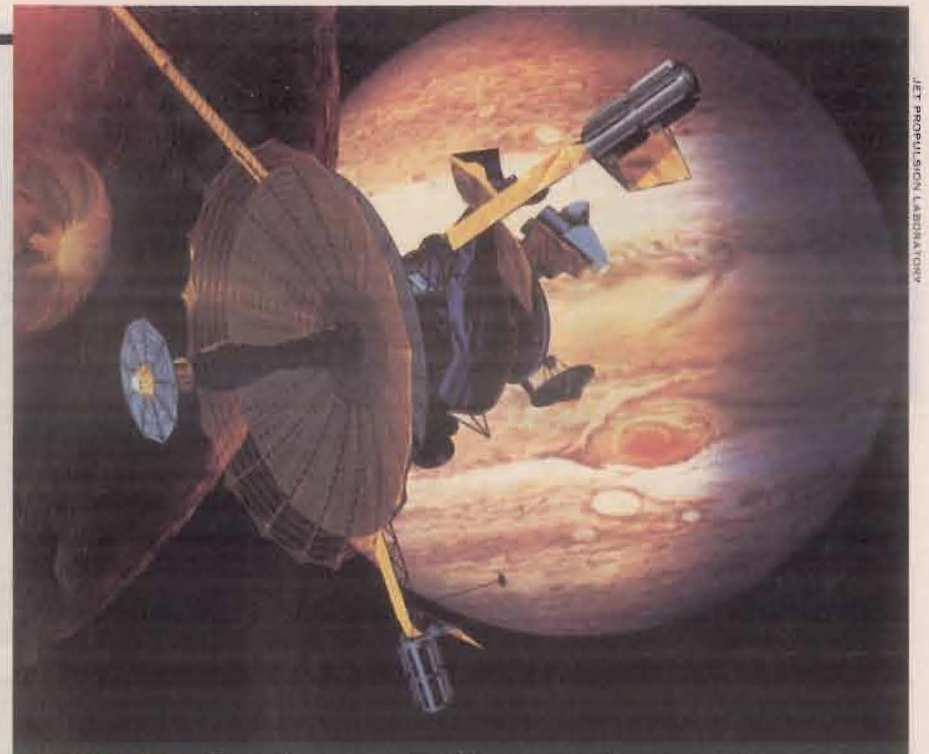
COMET OF 44 B.C. Appearing just after the assassination of Julius Caesar, it was believed by Romans to be their leader's soul on its way to join the gods. This "shooting star" was emblazoned on Roman coins.

GREAT COMET OF 1577. One of the brightest ever seen, it helped astronomers realize that comets travel on expansive orbits around the sun.

COMETS OF 1664 AND 1665. Superstitions reached a pinnacle, as astrologers foretold of scandals, persecution and a rise in debauchery.

HALLEY'S COMET, 1910. Making its periodic visit (every 76 to 79 years), Halley's swept so close that astronomers predicted Earth would pass through its tail. That prospect caused worldwide panic over exposure to supposedly toxic space gases.

COMET KOHOUTEK, 1976. Billed by astronomers as the sky show of the century, Kohoutek proved a bust, with little to be seen from Earth.



JET PROPULSION LABORATORY

BEST VIEW The Galileo spacecraft will have the only direct line of sight on the dark-side collisions. But will its temperamental instruments work?