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The Comet About to Smash into Jupiter

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Artist's conception of the collision of Comet Shoemaker-Levy 9 with Jupiter, as seen from the Galileo spacecraft. At the time of the first impact, the comet fragments will be much farther apart than shown in this illustration. (Courtesy D.A. Seal/JPL)

For a period of about six days centered on July 19, 1994, fragments of Comet Shoemaker-Levy 9 are expected to collide with Jupiter, the solar system's largest planet. Now such event has ever before been available for study. The energy released by the larger fragments will be more than 10,000 times the energy released by a 100-megaton hydrogen bomb! Unfortunately for observers, the collisions will occur on the night side of Jupiter, the back side as seen from Earth. How did this comet fragment? And what do astronomers think will happen when it hits?

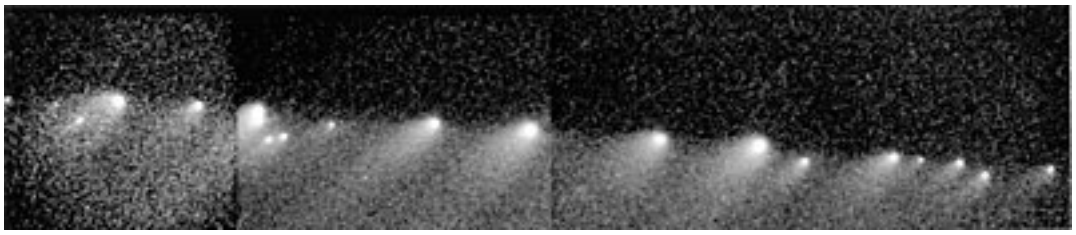
What is Shoemaker-Levy 9?

Comet Shoemaker-Levy 9 was discovered photographically the husband and wife scientific team of Carolyn and Eugene Shoemaker and amateur astronomer David Levy on March 24, 1993, using the 0.46 meter (18-inch) Schmidt telescope at Palomar Observatory in Southern California. Its discovery was a serendipitous product of their continuing search for "near-Earth objects,'' those whose orbits bring them closer to the Sun than the, Earth's orbit and thus have some potential for collisions with Earth. The "9'' indicates that it was the ninth short-period comet (i.e., with a period, or the time it takes to orbit the Sun, less than 200 years) discovered by this team.

The appearance of the comet was reported as "most unusual": the object appeared as a "dense linear bar'' with a "fainter, wispy tail.'' The comet's brightness was reported as about magnitude 14, more than a thousand times too faint to be seen with the naked eye. Latter observations revealed that the "bar'' was made up of as many as 21 pieces "strung out like pearls on a string,'' according to one researcher.

Soon astronomers had enough observations of the comet's position to determine its orbit. Unlike most comets that orbit the Sun, Shoemaker-Levy 9 seemed also to be in orbit around Jupiter. One orbit, computer May 18, 1993 by Syuichi Nakano, showed that the comet passed close to Jupiter in July 1992,

and would pass within 45,000 kilometers of the center of Jupiter in July, 1994. This distance is less than the radius of Jupiter. In other words, it appeared the comet would hit Jupiter.



This mosaic of images of Shoemaker-Levy 9, taken by the Hubble Space Telescope after it was repaired, shows some 20 of the fragments. (Courtesy H. Weaver/STScI)

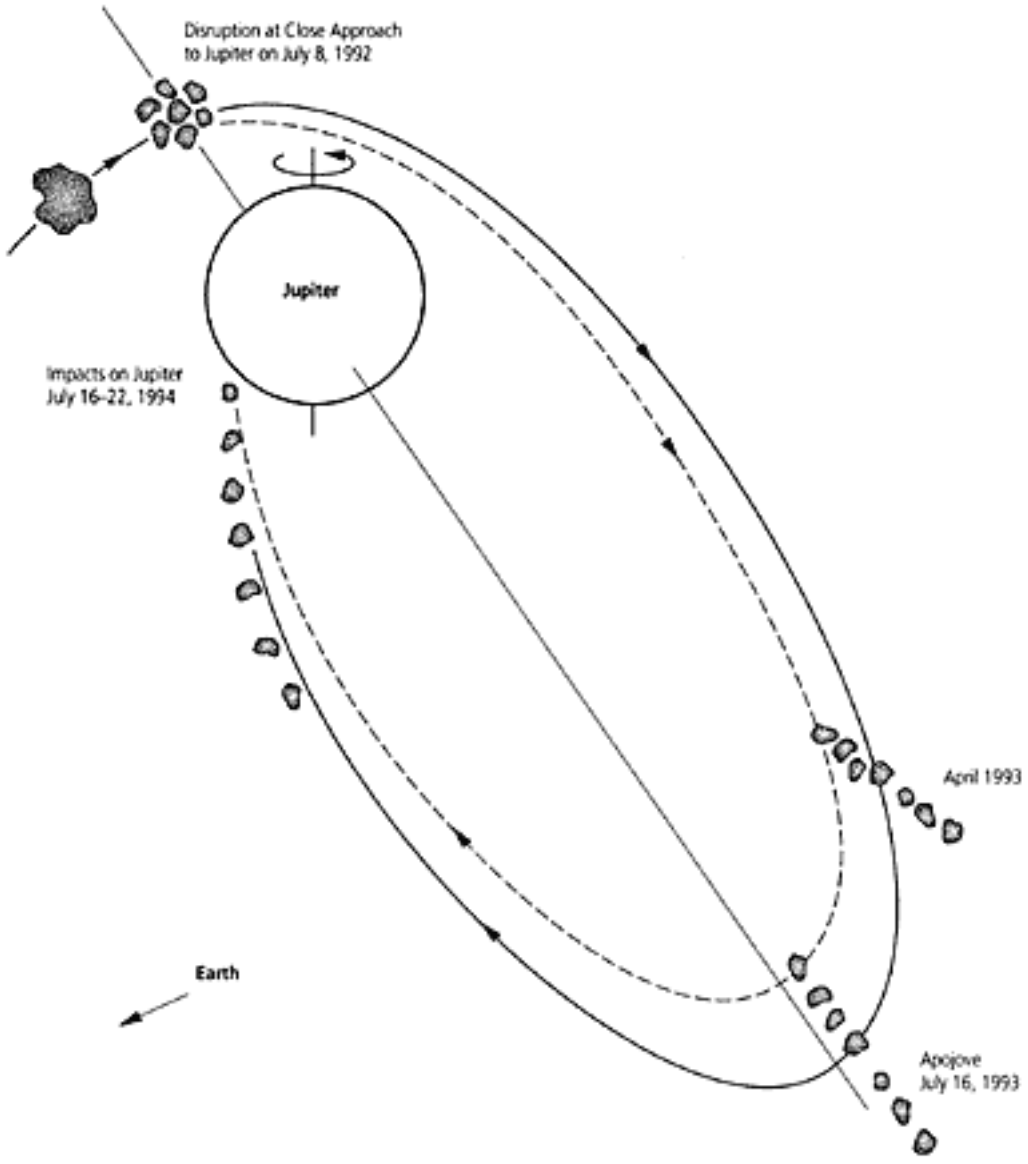
What caused the comet to break apart?

Comets are small, irregularly shaped bodies composed of a mixture of tiny pieces of rock and frozen gases. Most become visible only when they get near enough to the Sun for the Sun's radiation to turn the ices directly to gas, and the gas, in turn, blows away bits of the solid material and forms the extended gas and dust tails we associate with comets. The best evidence suggests that comets are very fragile. You could take a big piece of cometary material and simply pull it in tow with your bare hands, something like a poorly compacted snowball. Some 25 comets have been observed to split over the past two centuries. A few disruptions have been obviously attributable to the tidal forces of Jupiter or the Sun, while other splittings have less obvious causes, for example, the rapid rotation of a nucleus weakened by the loss of gas and dust.

On July 7, 1992, Comet Shoemaker-Levy 9 passed only 25,000 kilometers (15,500 miles) above the clouds of Jupiter, according to the latest calculations. The differential pull of the planet's enormous gravitational force on the near and far sides of the comet fragmented it into 21 or more large pieces and an enormous amount of smaller debris. It had been in a rapidly changing orbit around Jupiter for some time before this, probably for at least several decades. It did not fragment during earlier approaches to Jupiter, however, because these were at much greater distances than that of 1992; the comet probably approached no closer than about nine million kilometers in the orbit prior to that of 1992.

It is unlikely that the exact circumstances of the breakup of Shoemaker-Levy 9 will ever be known with certainty. But one model suggests that the original comet cannot have been much smaller that 9 kilometers (6 miles) in diameter and that it probably was rotating quite rapidly (perhaps once every eight hours.) The breakup and subsequent collisions between the fragments were not completed until about two hours after closest approach to Jupiter. All of the large fragments were soon strung out in nearly a straight line that pointed at Jupiter, and they will remain so until colliding into the planet.

At discovery in March 1993, the train of fragments was about 50 arcseconds or 162,000 kilometers in length as projected on the sky. (A circle is divided into 360 degrees, each degree into 60 minutes, and each minute into 60 seconds. The word "arc'' is added to denote angular measure rather than time. For example, the diameter of the Moon is about 30 arcminutes.) This linear distance had increased by about 50 percent by the time the comet was lost in the glare of the Sun in July 1993. The spreading is caused mainly by the fact that the piece closest to Jupiter at breakup was some nine kilometers closer than the farthest piece (the diameter of the comet) and therefore entered a faster orbit. The fragment nearest to Jupiter at breakup remains nearest to it and will be the first to impact. Astronomers predict that the train will reach an apparent length of some 1,286 arcseconds at the time the first of the fragments enters Jupiter's atmosphere. The true length of the train will be 4,900,000 kilometers, and it will require 5.5 days for all of the major fragments to impact.



The fragments of Shoemaker-Levy 9 move around Jupiter. This schematic is not drawn to scale. For example, the distance to apojove (the comet's farthest distance from Jupiter) is actually almost 1,200 times the distance from Jupiter at which it was disrupted, and the true representation would be a long narrow ellipse that looks almost like a straight line out and back. The length of the line should be 350 times the diameter of Jupiter and the disruption a tiny dot less than a quarter of the diameter above Jupiter. (Courtesy Z. Sekanina, P.W. Chodas, and D.K. Yeomans)
