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## By Jupiter! Comet crashes dazzle and delight

This week, humans watched as two worlds collided. More than 20 kilometer-size shards of a comet, most likely born in the frigid abyss beyond Pluto, crashed into the solar system's largest planet.

Jupiter took a bruising as the fragments of Comet Shoemaker-Levy 9 plowed one by one into the far side of the gas giant's southern hemisphere, collectively depositing the energy equivalent of some 40 million megatons of TNT.

Observers on Earth and spacecraft orbiting our planet couldn't see the actual impacts. But the fireworks recorded by myriad telescopes — some even before the crash sites rotated into view — exceeded the expectations of astronomers, who had worried that the highly publicized, 6-day event might prove a fizzle — another Comet Kohoutek.

Within the first few hours, such concerns proved groundless. Astronomer Heidi B. Hammel from the Massachusetts Institute of Technology raced into the auditorium of the Space Telescope Science Institute (STSI) in Baltimore waving aloft a dramatic new image. Hubble had recorded a dark pockmark created by the first fragment to strike Jupiter — even though that fragment was one of the puniest in the lineup.

"It's not a once in a lifetime [event], it's once in a millennium," declared comet codiscoverer Eugene M. Shoemaker after taking a swig from the bottle of champagne offered by Hammel. Subsequent pictures backed his assertion.

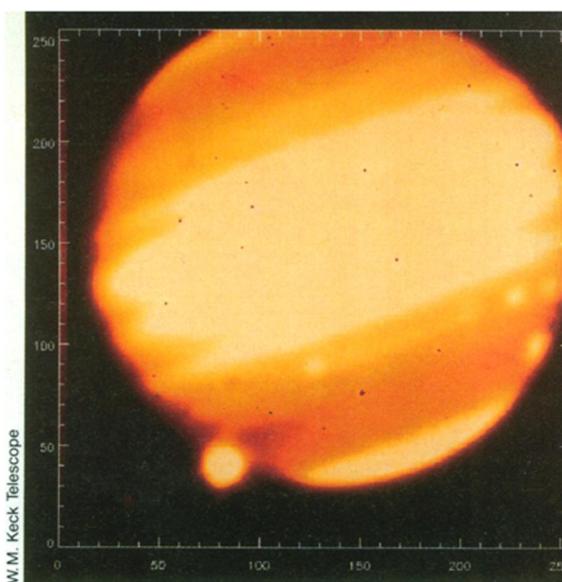
Emerging from the holes punched in Jupiter's atmosphere by the exploding fragments, plumes of hot, dark material rose higher than 1,000 km above the planet's visible cloud tops. Hubble images showed that the plume associated with fragment G — the seventh to strike and probably the biggest — had spread out within 90 minutes to cover a region in Jupiter's stratosphere equal to that of

Earth's diameter.

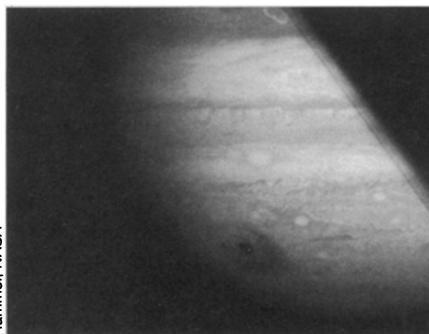
As if nature had conspired to play a practical joke, this splotchy blemish resembles a black eye floating in the planet's upper atmosphere. Clark R. Chapman of the Planetary Science Institute in Tucson reported midweek that the brightness and relative contrast of this feature in visible light had made it the single most prominent marking on the disk of Jupiter, exceeding even the planet's Great Red Spot.

By week's end, a narrow swath girdling Jupiter's southern hemisphere displayed other bruises, many of which may take weeks or even months to fade away.

Several mysteries emerged during the week. Many astronomers were puzzled that the plumes appeared dark in visible light. They had predicted that these



False-color infrared image taken by the W.M. Keck Telescope captures hot gas bubbles created when third (left) and first Shoemaker-Levy 9 pieces struck Jupiter.



The impact zone of fragment G, the seventh, shows a complex pattern of circles that resembles a black eye. The fragment may have struck the center of the sharply defined dark ring.

bly from Jovian material dredged up from deeper in the planet's atmosphere.

To the surprise of some astronomers, no one quickly captured a definitive chemical signature for cometary debris, including carbon, thought to be abundant in comets. Ultraviolet spectra taken by Hubble do show a marked increase in ammonia vapor in the vicinity of the seventh fragment. According to STSI's Keith S. Noll, this suggests that the exploding fragment vaporized ammonia ice, which got carried aloft.

A third possibility: The dark material might consist in part of new molecules forged in the hot plume. Supporting this scenario, SCIENCE NEWS learned that astronomers studying one of the early impacts have found evidence of two chemical species never seen before on Jupiter — methylene and the hydroxyl ion.

Both species would seem to require high heat to be formed, says Thomas R. Geballe of the U.K. Infrared Telescope on Hawaii's Mauna Kea. He and Steven Miller of University College in London base their finding on infrared spectra obtained with the telescope.

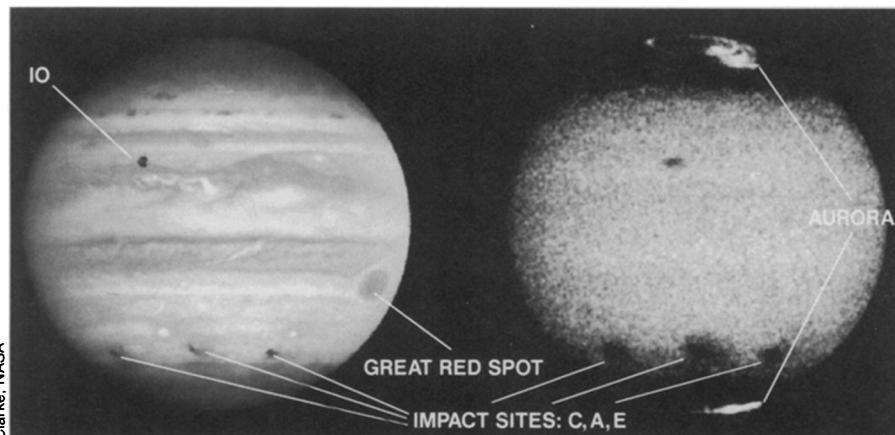
Ultraviolet images of the plumes will help probe the upper atmosphere, says John T. Clarke of the University of Michigan in Ann Arbor. Because ultraviolet images examine high-altitude features, tracking the expanding plumes at these wavelengths may for the first time indicate the wind speed of Jupiter's upper atmosphere, he says.

Not everyone was completely thrilled with the week's cornucopia of plumes and pockmarks. Reta F. Beebe of New Mexico State University in Las Cruces said she would have preferred "two or three or four events nicely spaced out." Instead, she notes, because of the many powerful crashes and the fact that some will probably overlap, it will be much more challenging to disentangle the effect of each.

— R. Cowen

smudges would appear white — the color of ammonia or water vapor condensing from the cooling plumes to form ice.

Harold A. Weaver of STSI conjectures that the dark color might indicate the presence of silicates or tarlike hydrocarbons. Such debris could come from the exploded cometary fragments or possi-



Comparison of violet (left) and far-ultraviolet images of Jupiter taken with the Hubble Space Telescope show three impact sites of Comet Shoemaker-Levy 9. Each image depicts (from left to right) the third (C), first (A), and fifth (E) impacts. The Jovian moon Io orbits above the planet.