Galileo: Jovian crash didn't breach clouds

Planetary scientists continue to debate the fundamental character of Comet Shoemaker-Levy 9 and its collision with Jupiter last July. How big were the comet fragments? How far did they penetrate into Jupiter's atmosphere? How much of the exhumed material came from the comet rather than from Jupiter?

Because the fragments struck the back of Jupiter, Earthbound telescopes could not view them directly (SN: 12/17/94, p.412). Now, the Galileo spacecraft, the only eyewitness to the impacts, weighs in with some tentative, but surprising, answers to these questions.

Researchers reported this week that infrared spectra from Galileo suggest that comet fragment G exploded high in Jupiter's atmosphere, never penetrating the uppermost cloud layer. And a preliminary analysis of much weaker spectra from the R fragment, which Galileo radioed back to Earth in January, supports this conclusion.

Fragments G and R may only have breached Jupiter's upper troposphere or lower stratosphere before exploding, says Robert W. Carlson of NASA's Jet Propulsion Laboratory (JPL) in Pasadena, Calif. This would place the explosions just above the layer of condensed ammonia that constitutes Jupiter's uppermost cloud deck. He and his colleagues base their analysis on data recorded by the craft's near-infrared mapping spectrometer (NIMS).

According to Carlson, the spectra suggest that even the G fragment, thought to be the largest, had a diameter smaller than half a kilometer and a composition as fragile as a loosely packed snowball. He adds that if other studies confirm that the fragments exploded high in the atmosphere, it would mean that much of the debris generated by the explosions came from the fragments themselves, not from Jupiter. Paul R. Weissman of

Carlson et al./JPL

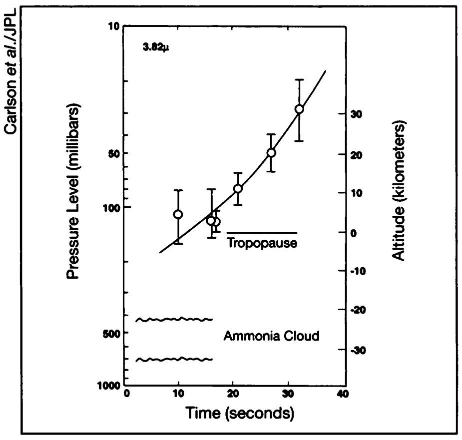


Diagram tracks explosion of Shoemaker-Levy 9 's fragment G, recorded by Galileo's infrared spectrometer. Ten seconds after explosion, fireball's top lay well above Jupiter's ammonia cloud layer.

Carlson's team reported the findings at the annual Lunar and Planetary Science Conference in Houston.

Each explosion's fireball radiated much of its energy in the infrared; NIMS recorded the light show from four impacts, including the G and R fragments.

Carlson and his collaborators find that 5 seconds after the G fragment exploded, its fireball had reached a diameter of 20 km and a temperature of 4,000 kelvins. After 40 seconds, the fireball, expanding at the rate of about 2 km per second, had ballooned to 80 km across and cooled to 1,300 kelvins.

NIMS also provided researchers with another key measure. To reach Galileo, infrared light had to pass through whatever depth of Jovian atmosphere lay above the fireball. Atmospheric methane and molecular hydrogen absorb some of the light, leaving dark absorption lines in the spectra. From the intensity of the absorption, Carlson's team deduced that relatively little atmosphere resided above the G fireball and that the fragment probably hadn't plowed deeply into Jupiter.

Carlson cautions that Galileo could only see the tops of the fireballs. And though he deems it unlikely, he notes that the fragments might have plowed deeper, their radiation hidden by clouds.

Because spectra taken by the Hubble Space Telescope appeared to betray the presence of large amounts of sulfur, some researchers have argued that the fragments did burrow deeper — breaching a layer of ammonium hydrosulfide believed to lie beneath the ammonia clouds (SN: 7/30/94, p.68).

But Keith S. Noll of the Space Telescope Science Institute in Baltimore told SCIENCE NEWS that new calculations show that Hubble had detected much less sulfur. The revised estimate may strengthen the case for a high-altitude crash, Carlson says. — *R. Cowen*

Boosting the accuracy of a relativity test

Scheduled for launch in 1999, Gravity Probe B represents an ambitious attempt to test the general theory of relativity. By measuring tiny changes in the tilt of four gyroscopes aboard this Earth-orbiting satellite, physicists hope to detect certain subtle gravitational effects predicted by the theory.

Now, a researcher has proposed an alternative design that could make the experiment up to 1,000 times more accurate. Such an improvement would enable scientists not only to test general relativity but also to distinguish between various competing theories of the evolution of the universe.

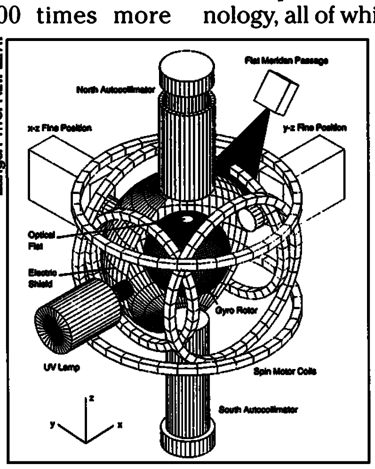
Benjamin Lange of Stanford University describes his design in the March 13 PHYSICAL REVIEW LETTERS.

According to general relativity, a star or planet warps the geometry of space and time in its vicinity. As it rotates, such a body also "drags" this spacetime distortion with it. These effects cause the spin axis of a gyroscope in orbit around the body to drift slightly.

The original design of Gravity Probe B called for the use of four gyroscopes, each an ultrasmooth quartz ball coated with niobium. The niobium layer becomes a superconductor at liquid helium temperatures, allowing the balls to be suspended in space by electrical forces. Sensitive magnetometers detect any changes in the tilt of a gyroscope's spin axis (SN: 3/3/90, p.143).

Lange's design uses a single gyroscope with a silicon rotor suspended in a rapidly spinning satellite operating at ambient rather than liquid helium temperatures (see diagram). The higher temperature allows use of a more sensitive detection technique. "It is based on existing technology, all of which can be tested prior to flight," Lange contends.

Lange/Phys. Rev. Lett.



Proposed gyroscope design.

"It's a very interesting idea," says Stanford's Francis Everitt, a principal investigator on the Gravity Probe B project. "But I don't think Lange's approach is necessarily superior. All of the issues haven't been addressed."

Moreover, NASA has already spent more than $230 million on the project, and much of the hardware has been built. "There's no way that we can change horses in midstream at this stage in the program," Everitt insists.

However, continued funding for Gravity Probe B now depends both on the outcome of a review by a National Academy of Sciences committee and on whether NASA can propose budget cuts to offset the $51.5 million designated for the project in fiscal year 1996.

"My proposal offers an alternative way of continuing the program," Lange says. — *I. Peterson*