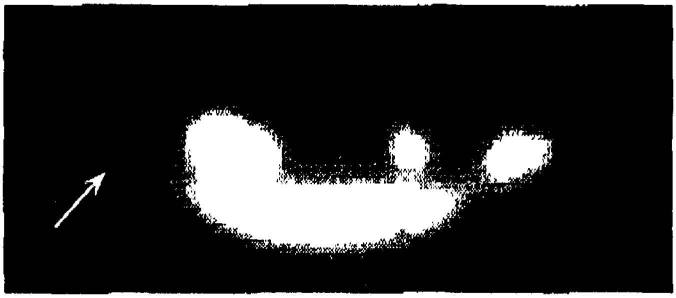
Since the IAU meeting, we have reduced new, more sensitive lightcurves and accounted for saturation effects. These data now show *two* separate precursors for the H and L impacts rather than just one. We believe that the first precursor marks the meteor entry, the second is the expanding fireball, and the main event observed by infrared ground-based telescopes is due to ejecta from the primary impact reentering the jovian atmosphere.

Finally, we see evidence, in the form of a faint spot, for an unknown fragment that struck Jupiter at least forty minutes before the main L impact. The spot is visible in reflected light in nearly 100 frames covering the twenty minute period from 21:56 to 22:16. One of these frames is displayed in Fig. 1. In this highly stretched image, the south polar hazes and the scars from the previous K, C, and A impacts (left to right) appear to be merged. Two of the south temperate ovals can be seen as faint blobs slightly north of the C spot and west of the central meridian. The L mystery spot is clearly visible near the south-eastern limb, just to the left of the bright K complex. We suspect that this spot is the impact scar of the lost J fragment, although a small previously unknown SL9 fragment cannot be ruled out.



AAT OBSERVATIONS OF COMET SHOEMAKER LEVY-9 COLLISIONS WITH JUPITER

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We used the InfraRed Imaging Spectrometer (IRIS) on the Anglo Australian Telescope to monitor the collisions of Comet Shoemaker-Levy 9 fragments C, D, G, K, N, R, V, and W with Jupiter. We also monitored the impact sites for up to 10 hours each day from 16 to 23 July UT 1994. IRIS is a near-infrared camera/spectrometer with a 128 by 128 element Mercury–Cadmium–Telluride (NICMOS2) detector. This instrument was used primarily as an imaging spectrometer for these observations. In this mode, each

2-minute north-south scan produced a full-disk spectral image cube of Jupiter at 128 wavelengths in H-band (1.4 to 1.8 μm) or K–band (1.98 to 2.38 μm), with a spatial resolution of 0.6 arcsec/pixel. Of the impacts that we observed, fragments G and K produced the brightest K–band impact flashes. Fragment V produced the least intense impact flash. The main flash was usually preceded by one or more faint precursor events. The precursors for fragments G, K, and W were seen within 40 seconds of the impact flashes detected by instruments on the Galileo spacecraft. These faint flashes provided the first evidence for the entry of the fragment into the Jovian atmosphere, but we do not yet know if they were associated with the bolide, or the initial evolution of the fireball. The maximum K–band brightness was observed 8 to 10 minutes after this event. The impact flashes for fragments G and W reached their peak K–band brightnesses just as the Hubble Space Telescope observations indicated that the visible fireball had reached its maximum altitude above the limb. K–band spectra of both the precursor and main impact flashes were initially dominated by continuum emission with color temperatures near 700 K. As the continuum emission subsided for fragments C, D, G, K and R, bright CO emission lines appeared at wavelengths longer than 2.29 μm. The strong emission in the CO 2–0, 3–1, and 4–2 bands indicates that this gas had recently been exposed to temperatures exceeding 2000K, or that it had recently been formed in exothermic chemical reactions. These results provide only an upper limit on the kinetic temperatures of the plume, because the CO may not have been in local thermodynamic equilibrium at the very low pressures where its emission was observed.

The initial dominance of continuum emission over line emission in both the precursor and main flashes suggests that these phenomena are associated with emission from hot particulates rather than gases in the rising impact plume. The largest particles in the rising plume are probably much hotter than the gases because the gases will cool adiabatically as the plume rises and expands, while the large particles must cool almost entirely by thermal emission (conductive cooling to the surrounding gas is very inefficient for particles with diameters greater than 1 μm at pressures less than 10 mbar). Hot gases associated with the collapse and splash-back of the plume into the upper atmosphere would produce line emission instead of continuum emission. The intense CO line emission seen after the plume had reached its peak altitude may have been produced by chemical reactions or shock heating associated with a "splash-back" event.

Once the impact sites had rotated onto the Earth-facing hemisphere of Jupiter, they appeared as bright clouds that were often as large as the Great Red Spot. These clouds had their highest contrast at wavelengths within strong methane bands near 1.77 and 2.3 μm, where the Jovian disk is very dark. A preliminary modeling study indicates that the appearance of these impact sites can be simulated by an optically-thin ($\tau > 0.25$) cloud consisting of small ($\sim 0.25\,\mu$m), reflective ($\omega > 0.97$) particles, located above the 1 mbar level.

SAAO OBSERVATIONS

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Coverage of the impacts was obtained at K(2.2μm) with a PtSi array camera on the 0.75m telescope at Sutherland. Continuous exposures were made in parallel with the readout. The weather was clear and all accessible events were observed successfully.

The following table summarizes the observations:

Table I - Time coverage of continuous integrations

Date(1994)	Time (UT)	Integr. (secs)	Fragment
16 July	1939-2040	30	A
17 July	1430-1600	30	E
18 July	1900-1950	30	H
20 July	1445-1600	10	P2
20 July	1900-2040	10	Q1,Q2
21 July	1445-1545	30	S
21 July	1745-1900	30	T

In addition, photometry was obtained at K using the infrared photometer on the 1.9m telescope by D.C.B. Whittet and J. Shykula (Renselaer Polytechnic Institute, New York, USA).

JWM assisted Matt Senay (University of Hawaii) at the 1.0m telescope, equipped with CCD camera and coronagraph, in an attempt to image the comet as well as to detect flashes from the limb during impact and possible plumes post-impact. Narrow-band Na and CH_4 filters were used. Severe technical problems were experienced with the coronagraph and useful results may be difficult to extract.