HUBBLE SPACE TELESCOPE VISIBLE IMAGING OF JUPITER DURING THE COMET CRASH

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In July 1994, the fragments of Comet Shoemaker-Levy 9 plunged into Jupiter. We present preliminary results from analysis of the Hubble Space Telescope (HST) imaging observations of Jupiter obtained before, during, and after the impacts. We discuss observations of observed phenomena ranging from plumes to waves to atmospheric evolution. We report positions of all detected impact sites (we could not locate F, P2, T, U, and V). By comparing predicted and observed impact longitudes, we estimate the actual impact time. On average, impacts occurred about 8 minutes later than predicted, although this varied from on time to more than 15 minutes late. We also present an assessment of the relative size of the disturbance for each event.

HST images showed the development of several of the erupting plumes (A, E, G, and W) over a period of about 20 minutes. In three cases (A, G, and W), we may have detected the incoming bolide, although alternative explanations for pre-plume flashes are possible. For fragments E, G, and W, we detected the

10 to 15 km/sec. A fascinating and unexpected feature of the impact plumes is that they all appear to reach the same height (about 3300 km) regardless of the size of the impactor that generated them. This point greatly confounded the impact modelers, who planned to use the plume heights to estimate the diameter of the impacting comet fragments.

Figure: Image of Jupiter by NASA's Hubble Space Telescope. The large feature with a central dark spot and concentric rings was created by the impact of fragment G of Comet Shoemaker-Levy 9 on July 18, 1994. Fragment G entered Jupiter's atmosphere from the south at a 45-degree angle, and the resulting ejecta appears to have been thrown back along that direction. The smaller feature to the left of fragment G impact site was created on July 17 by the impact of fragment D. This image was taken 1 hour and 45 minutes after fragment G impacted the planet.

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During the impact of the W fragment, the Galileo spacecraft and HST were observing simultaneously through nearly identical filters; both detected a signal near the limb of the planet. The bright, rapid flash seen by Galileo's cameras was interpreted as the incoming bolide, but from HST's vantage point, this should have been behind the planet's limb, and hence invisible. What did the HST detect? One possibility is a flash reflected off either a dust trail following behind the comet fragment, or a cloud of high altitude debris deposited by dust which preceded the fragment into Jupiter's atmosphere. Alternatively, HST may have detected the beginning of the fragment's glowing, meteor-like interaction with Jupiter's thin upper atmosphere.

Atmospheric waves were detected immediately following the impacts of A, E, G, Q1, and R; the HST images revealed concentric rings spreading out from the largest impact sites, yielding a wave-front speed of 454 +/- 20 m/sec. The rings spread more slowly than the slowest acoustic wave, which propagates at the altitude of the temperature minimum at 800 m/s. Gravity waves bracket the observations, but the mechanism that selects out the particular speeds that were observed has not been identified. By successfully matching the observations, we may learn more about the vertical distributions of ambient temperature and energy release from the impacts.

The ballistic ejecta forming the plumes fell back on the upper stratosphere of Jupiter, heating huge areas of atmosphere, typically about the diameter of the Earth, or more. As these huge hot clouds of debris rotated into view from the Earth, they produced immense infrared brightenings and large dark clouds seen by ground-based observers. The morphology of the debris clouds should provide clues to the impactors' penetration depths, and thus, their sizes. We discuss both the evolution of selected sites by the jovian winds, and the overall change in Jupiter's appearance as a result of the bombardment.

HUBBLE SPACE TELESCOPE FAR-ULTRAVIOLET IMAGING OF JUPITER DURING THE IMPACTS OF COMET SHOEMAKER-LEVY 9

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