Post-impact Improvements in the Orbit Solutions of the S1.9 Fragments

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The impacts of the fragments of comet Shoemaker-Levy 9 (SL9) were observed by a wide variety of ground-based and space-bawd instruments. The times of eight of the impacts are known to within seconds from data returned by the Galileo spacecraft, which had a direct view of the impacts. Less accurate estimates of the impact times for another eight events have been inferred from ground-based infrared lightcurves. The impact times predicted from the orbital solutions were systematically early by an average of -7 minutes. The most likely reason for this bias is the presence of systematic errors in the reference star catalogs used in the reduction of the astrometric measurements. In an effort to make the orbit solutions consistent with the observed impact times, the orbit determination software was modified to use the impact time as a new type of astrometric measurement. When impact times were included in orbit solutions, the astrometric residuals changed by no more than a few tenths of an arc second, well within the possible range of systematic star catalog errors, The residuals for all fragments observed in a single astrometric image are clearly correlated, with a bias generally much larger than the scatter. By averaging the residuals in each astrometric image, the star cat slog biases were estimated. After these biases were removed from the observations, and a second set of new orbit solutions were computed. Since these new solutions accurately predicted the impact times without the use of the impact time measurements, they should accurately estimate the impact times of fragments whose impacts were not observed. With the star catalog biases removed, the final set of orbit solutions for the S1.9 fragments had weighted rms residuals of less than 0.3 arc.see, the smallest of any comet to date.